MORPHOLOGY

AND

ANTHROPOLOGY

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A HANDBOOK FOR STUDENTS

BY

W. L. H. DUCKWORTH, M.A.,

FELLOW OF JESUS COLLEGE, CAMBRIDGE;

UNIVERSITY LECTURER IN PHYSICAL ANTHROPOLOGY;

CORRESPONDANT ÉTRANGER DE LA SOCIÉTÉ D'ANTHROPOLOGIE DE PARIS

TO HENRY DUCKWORTH, ESQ., J.P.,
F.L.S., F.G.S., F.R.G.S.

PREFACE.

AS the Introductory Chapter of this Volume deals with its aim and scope, any further exposition of these would be superfluous here. I hope that the materials thus brought together may prove useful to Students, particularly to those who combine Physical Anthropology with Human Anatomy in preparation for the Cambridge Natural Sciences Tripos. Inasmuch as such students are already familiar with anatomical terms, a general acquaintance with the significance of these has been assumed.

I believe the method indicated, however inadequately, herein, to be the most profitable for anthropological work on the physical side: and I am convinced that upon some such basis only, can Physical Anthropology justify its claim to an independent place among the biological sciences.

The subject is now perfectly well-defined, and possesses so extensive a literature, that even a cursory review like the present volume has assumed proportions for which I must offer an apology. Several departments of the subject (and particularly Anthropometry) have merely been sketched in outline. A certain amount of repetition will be noticed, but is justifiable in view of the greater completeness conferred upon successive sections of the book. Most of the illustrations have been prepared by myself, in many instances from the original specimens or preparations.

Like other reviews, this cannot be other than a process of stocktaking. I have attempted to submit the main points in evidence up to date; yet however desirable an absolutely fixed standpoint may appear, it should not be forgotten that opinion must be adjustable to the requirements of every new fact, provided the latter be correctly observed and accurately recorded.

It is a pleasant duty to express my gratitude to those who have aided me; to my father, and to Professor Alexander Macalister, for ever-ready help and encouragement; to Professor Elliott Smith and to Dr Marett Tims, who kindly read parts of certain Chapters (viz. XV. and VI), upon the subject-matter of which they are recognised as authorities of the highest competence.

Mr F. S. Scales, of Jesus College, Cambridge, gave me most valuable help in preparing the illustrations for reproduction. My warm thanks are also due to the Editor of the Biological Series, and to the authorities and staff of the University Press at Cambridge.

The following have kindly lent blocks for illustrations, or have given permission to copy figures in other publications: Dr Nelson Annandale, late of Edinburgh, now Assistant Curator at the Calcutta Museum; M. J. Deniker and Messrs W. Scott and Co.; Professor E. Dubois; Professor Elliott Smith; Sir H. H. Johnston, G.C.M.G., K.C.B.; Professor Kollmann and Messrs Fischer, of Jena; Messrs Macmillan and Co.; Mr Parsons; Professor Schwalbe and the Redaktion of the Bonner Jahrbücher; the late Professor Selenka and the Königliche Akademie der Wissenschaften zu München; Professor Strahl and Messrs Kreidl, of Wiesbaden.

The following have allowed the use of tables or information already published elsewhere:

Dr Ballantyne and Professor Cunningham of Edinburgh; Professor Eisler of Halle and Professor Le Double of Tours; Professor Parker and Haswell and Messrs Macmillan and Co.

I have endeavoured to render full acknowledgement, and hope that no omission has been made. References to literature are provided in the text: a special index contains the names of authors quoted. Where possible, I have attempted to verify or check statements by personal observation.

ADVIE,
    STRATHSPEY.
        Oct. 21, 1904.

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ADDENDA AND CORRIGENDA.

PAGE

281. For " Eltung " read " Elting."

288. In the legend of Fig. 188, for " enselline " read " ensellure."

311. Obliquity of the forearm. This is apparently less in the negro than in the white races.

321. For " Baetz," read " Baelz."

357. Fig. 216 was provided by M. Deniker with permission from Messrs W. Scott and Co.

426. In Figs. 247—254 incl., and 259—262 incl., the sulcus lunatus is denoted by the abbreviation S. lun.

462. At the conclusion of paragraph 2, add " The occurrence of typically Melanesian crania in such widely-separated groups as the Orang-Laut (of the Malay Peninsula), the natives of Rotuma, and the Bush natives of South Africa may thus become more intelligible. In the two former instances, however, actual migration may have taken place."

505. In reference to Fig. 317, note that a better specimen (at Paris) than that which is represented, shews that transverse ridges were present in the lower molar teeth of Mesopithecus, as in those of recent Cercopithecidae.

510. In footnote 2, line 5, for " it " read " is."

511. To footnote 2 it should be added that v. Branco has had the boldness to suggest that the Javan fossil discovered by Dubois was a hybrid.

514. Legend of Fig. 322 ; in the 3rd line, for N′ read N″.

ABBREVIATIONS.

The following are some of the abbreviations employed in footnotes :

Linn. Trans.—Transactions of the Linnaean Society.
Proc. Anat. Soc.—Proceedings of the Anatomical Society.
Proc. Zool. Soc.—Proceedings of the Zoological Society.
J. A. and P.
J. A. P. ⎫—*Journal of Anatomy and Physiology.*
Journ. of Anat. and Phys.⎭
Anat. Anz.—Anatomischer Anzeiger.
Proc. Philad. Acad.—Proceedings of the Philadelphia Academy of Natural Sciences.
Jahr. der Anatomie—Jahresbericht der Anatomie und Entwickelungsgeschichte.
Bibl. Zool.—Bibliotheca Zoologica.
Bull. de la Soc. d'Anthr.—Bulletins de la Société d'Anthropologie de Paris.
Am. Journal of Anat.—American Journal of Anatomy.
Chall. Rep.—Challenger Reports.
Z. für Ethn.--Zeitschrift für Ethnologie.
Journ. Anth. Institute.—Journal of the Anthropological Institute of Great Britain and Ireland.
Précis d'A.—Précis d'Anthropologie (Hovelacque et Hamy).
Cat. Mus. R. C. S.—Catalogue of the Specimens in the Museum of the Royal College of Surgeons, London.
Ergebnisse.—Ergebnisse über einer Forschungsreise nach Ceylan.
Bull. Am. Mus. Nat. Hist.—Bulletins of the American Museum of Natural History.

CHAPTER I.

INTRODUCTION.

In entering upon the study of the morphological aspects of Anthropology it is of the first importance to ascertain and realize the scope and limits of the subject. This is admittedly a somewhat difficult task, and the following account aims at giving some general information of an introductory nature.

The use of the term Anthropology is not modern, and when first employed[1] it referred in a general sense to human anatomy and physiology, the study of which was at the time referred to in a very elementary stage. In earlier days certain philosophers had been spoken of as anthropologists, and again in later times, *i.e.* in the 18th century, Anthropology was treated (by Kant and others) as a branch of philosophy, rather than of natural science. The latter end of the 17th century was a most important epoch in the history of Physical Anthropology, using the term in the sense which it has now acquired and which will presently be explained. It was in the year 1699 that Dr Edward Tyson, a member of Corpus Christi College, Cambridge, published under the auspices of the Royal Society a treatise entitled " Orang-Outang, sive Homo Sylvestris; or, the Anatomy of a Pygmie compared with that of a Monkey, an Ape, and a Man[2]."

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[1] In 1501 by a German, Magnus Hundt, of Marburg.

[2] In this work we find described system by system and organ for organ the comparative anatomy of man and a " Pygmie." Upon the evidence thus provided is based a discussion of the relations of the two forms, the differences as well as the resemblances of the two animals are taken into due consideration, and the author sums up to the effect that "our Pygmie is no Man, nor yet the Common Ape, but a sort of animal between both." The descriptions, the illustrations, and the skeleton of the " Pygmie " (now in the Natural History Museum, S. Kensington), shew that it was an immature Chimpanzee.

Without entering upon detailed criticism of this work it may be said that it constitutes a most remarkable anticipation of modern methods of research, and still serves as a model for investigations into the structure of Man and Apes (Fig. 1). Nevertheless
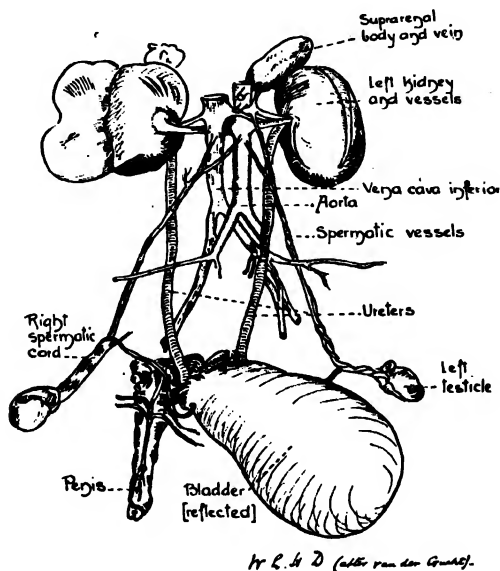
Fig. 1. Drawing of a dissection of the genito-urinary system of a Chimpanzee. From Tyson's "Orang-outang, sive Homo Sylvestris. Or, the Anatomy of a Pygmie." London, 1699.

although so important in these respects the work was not described as one on Anthropology, nor is it certain that Tyson made use of the term in connection with it.

The 18th century in turn affords several notable names in the history of Anthropology. The chief contributors to the subject were Linnaeus, Buffon, Camper[1], Lamarck, and Blumenbach,

[1] Born in 1722 at Leyden, Camper had reached the age of sixty-seven at the time of his death at the Hague. But for the work of Tyson, that of Camper would hold the place of honour as anticipating the soundest and most productive methods of modern physical anthropology. The most important of Camper's writings in this connection deal with the comparative anatomy of the orang-utan (a chapter being devoted specially to comparison with human anatomy), with the significance and origin of pigmentation in the negro races, and finally with a method of the comparative study of skulls, based upon the principle of projections, *i.e.* the comparison

of whom the first is distinguished by having deliberately included Man with other animals in his system of *classification*. Buffon studied the varieties of Mankind, and is credited with the application of the word "race" to the several modifications of the human type. Lamarck's name is inseparably associated with the enunciation of a theory accounting for the differences observed in the forms of animals.

Finally Blumenbach is distinguished particularly by his studies in comparative human craniology (cf. Fig. 3), a science of which he may be said to have laid the foundations[1].

of forms and contours drawn in rectilinear projection, so as to eliminate errors due to perspective such as occur when the object is observed in the ordinary way. In the latter treatise Camper defines and explains the use of the facial angle (cf. Fig. 2), which has subsequently remained.
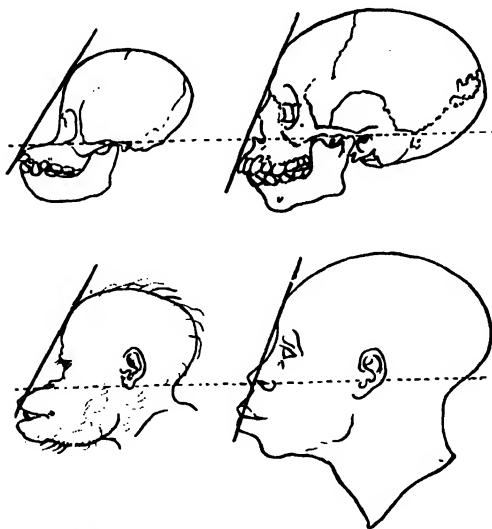
Fig. 2. Drawings of the head and skull of a young Orang-utan, and of a negro, to shew the method of determining the facial angle of Camper (cf. Chap. x.). From Camper's original memoir.

[1] So important are Blumenbach's contributions to Anthropology that a few notes on his work may not be out of place in this connection. Born at Gotha in 1752, Blumenbach studied successively at Jena and at Gottingen, at which latter University he obtained a professorial chair : and at Gottingen Blumenbach died in 1840. Three characteristics seem to be prominent before all others in the character of this remarkable man. His extraordinary versatility in scientific pursuits has rarely

This growing tendency to study Man as a zoological form shews the trend towards the modern conception of Physical Anthropology.
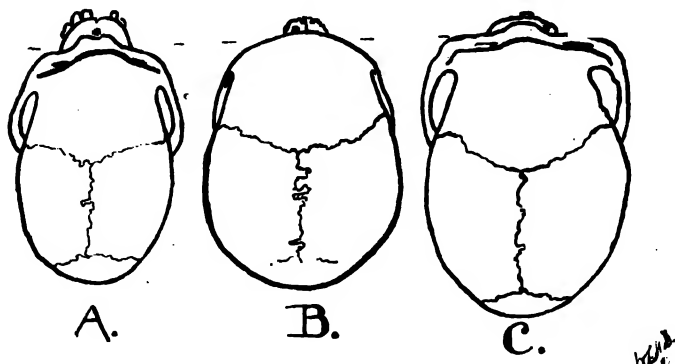
Fig. 3. Blumenbach's "norma verticalis" of three crania; A, an "Ethiopian"; B, a Georgian woman; C, a Tunguse. The different degrees to which the maxilla and the zygomatic arches project beyond the periphery of the cranial bones is to be noticed. (The figure is copied from that illustrating Blumenbach's works as translated by the Anthropological Institute.)

Another important epoch in the history of our subject is the earlier half of the 19th century; and it is particularly marked by

been surpassed, even in the fatherland of Goethe, v. Helmholtz, and Virchow. Scarcely less impressive was his enormous range of literary acquaintance. A third point is that he was eminently a laboratory worker (sesshaft, as the Germans style it), for he travelled but little.

Blumenbach's principal contributions to science consist of a treatise on the "Natural Varieties of the Human Species" and of numerous craniological descriptions, to which must be added certain essays on the Natural History of Man, including an anatomical comparison of Man with other animals. And the chief advances determined by these researches may be summarised as follows:

(1) The employment of the word "anthropology" as descriptive of morphological studies.

(2) Recognition of the fact that no sharp lines demarcate the several varieties of Mankind, the transition from type to type being imperceptible.

(3) The clear enunciation of a classificatory scheme of the varieties of Mankind, admittedly arbitrary, but devised with the object of facilitating study: the classification was based on considerations of the characters of the skin, the hair, and the skull.

(4) Recognition of the influence of external causes in producing and perpetuating variations in animals, including Man; recognition of the origin of varieties through "degeneration"; Blumenbach thus very nearly anticipated some important discoveries reserved for Darwin at a later date.

the foundation of societies for the scientific study of Man. The societies in question were founded in several countries, among which France and our own country took the lead. But the subject still remained in an undifferentiated condition, and the distinction between the studies of mental and physical attributes, or of nations and races, was not yet clearly marked. Such subdivision and specialization of study do not occur in the earlier phases of the life-history of a science, and Anthropology formed no exception to the general rule.

Anthropological Societies were founded, as has been mentioned, early in the 19th century, at an epoch when Hebraic cosmology was very generally and literally accepted. Against such literal acceptance there were not lacking protests; the progress of zoological study (perhaps especially the results of observations on the geographical distribution of animal forms) had cast doubt on that part of the account relating to animals other than Man, just as the birth and progress of scientific geology rendered necessary a revision of the opinion commonly held as to the history of the earth. These new creeds had not yet however gathered the force they were subsequently to acquire, and in particular the inferences drawn from them were not generally recognised as having an application to the special case of the origin of Man. None the less, certain French writers of the 18th century (Buffon and Lamarck) had clearly suggested the possibility of the evolution of new species by the transformation of pre-existing forms of life, and had applied this reasoning to the case of Man in common with other animals. By so doing they kindled a spark of controversy which, after smouldering for half a century, was destined to break out as a veritable conflagration soon after the founding of the Societies of Anthropology to which reference has just been made. The labours of those Societies received thereby a stimulus the importance of which can hardly be over-estimated. But the point which it is here desired to emphasize is, that the early work of the Anthropological Societies consisted largely in the study of the outward appearance and social status of the various races of Man; when to this there is added the study of racial differences in human crania, an idea will be formed of the nature of Anthropology in the earlier decades of the

19th century. The problems of the origin of Man and of his relation to other animals still remained to be added.

Anthropology thus received a wider application than heretofore, and further, it is to be noticed that two men in particular (Darwin and Huxley) were instrumental in thus extending and rendering more precise the morphological aspect of this subject. The chief merits of Darwin in this connection may be summed up in the statement that he not only suggested the principle of Evolution as an explanation of the existence of the many varied animal forms, but brought it vividly before a very large section of the public; that he on the one hand indicated a possible explanation of the method of Evolution and on the other hand demonstrated that the reasoning involved is applicable to
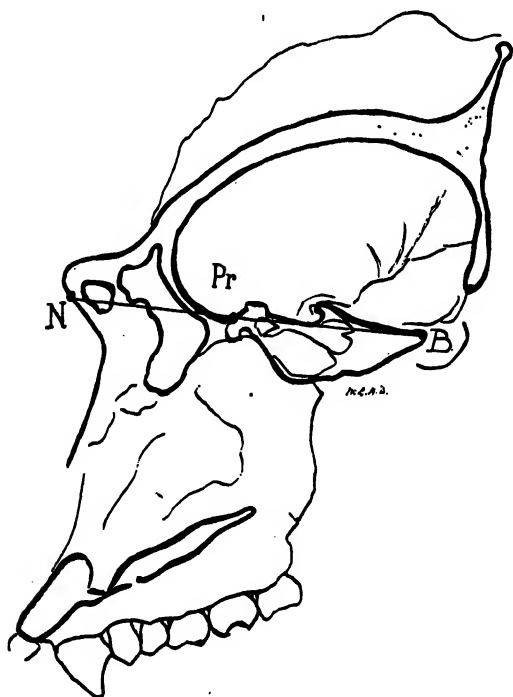
Fig. 4. The longitudinally-bisected skull of a male Gorilla: the line $B.Pr.N°$ represents the spheno-ethmoidal angle of Huxley, here equal to two right angles or 180°.

Man equally with other animal forms[1]. This work was very appropriately supplemented by that of Huxley, who enunciated clearly the conclusions as to the relations of Man to other animals, which would be arrived at by the application of the line of argument laid down by Darwin. Huxley's lectures[2] given in 1863 are still the best introduction to this part of the subject.

It is impossible here to enter into an historical account of the vicissitudes of what were
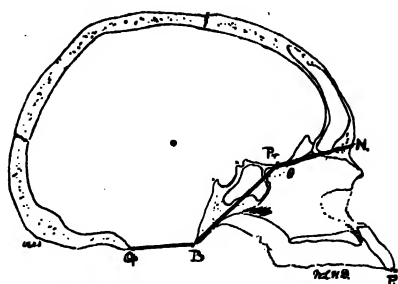
Fig. 5.   The longitudinally-bisected skull of an aboriginal native of Australia, with the lines shewn by which Huxley's spheno-ethmoidal angle (θ) is included (viz. BPr, and NPr).

at that date newly-published views as to the origin of Man: nor is it possible in this place to do more than mention the names of the chief contributors to the progress of the same in receiving acceptance. It is however important to notice that Anthropology soon proved to be a subject capable of almost indefinite extension. From the study of the external appearance of Man in all his varieties, the attention of students was turned, through the causes just mentioned, to the investigation of the structure of the human body, in other words to the study of Human Morphology. It is preferable in this connection to speak of Human Morphology rather than of Human Anatomy, for the former term implies the comparison of the architectural form of the human frame with those of other animals.

Not that the study of Human Morphology was a newly-discovered field for activity; and it is here that the interest that attaches to Tyson's work becomes manifest; for the keynote of the treatise to which reference has been made is the morphological aspect of anthropology as studied by means of a detailed comparison. Moreover, as we have seen, Peter Camper of Amsterdam had followed Tyson with a very remarkable contribution to the study of the skull. On the embryological side, Meckel and v. Baer in the early part of the 19th century had made discoveries of fundamental importance for the progress of the science.

[1] Cf. Darwin, *On the Origin of Species &c.*: and *The Descent of Man.*
[2] "Man's Place in Nature." Similar lectures were given by Carl Vogt in Geneva.

New, however, was the widespread recognition, first that the study of the origin of Man now demanded the attention and the interest of students of natural science, and secondly, that this problem, of which the solution had appeared so hopeless, might now be attacked by the same methods as were being applied with success to unravelling the origins of other members of the Animal Kingdom[1].

The range of anthropological studies was in this way very considerably enlarged about the middle of the 19th century. Soon there came a further extension: for the study of human crania (which has already been mentioned as forming a subsection of Anthropology from the time of Blumenbach) was now energetically pursued in various European countries. In this connection the names of Retzius, Huxley, Lucae, Virchow, Schaafhausen, Flower and Turner are of note, but above and beyond all these stands the French observer Paul Broca, whose work has had an almost incomparable influence on the study of Craniology[2]. This study

[1] The ancestry of the horse as demonstrated by Huxley is a good example in point.

[2] Paul Broca was born in 1824. Educated as a surgeon, he not unnaturally first published work dealing with surgical topics, such as the surgery of aneurism. In 1859 Broca published a contribution to biological literature entitled "Hybridity," pointing out the interest of the phenomena of hybridity in connection with the stability and fixity of animal species. In this work the special case of man is discussed, and doubt cast on the occurrence of Eugenesis, or the fertility of the offspring of individuals of strongly contrasted race; these doubts have been resolved in the negative.

In the same year (1859) Broca published the first of a long series of works upon the prehistoric inhabitants of Western Europe; the first contribution dealt with the Ethnology of France, shewing the effects of invasions upon the primitive autochthones of that land. Numerous essays on the human skeleton and particularly upon the skull followed. Attention was then diverted to the soft tissues, and like Blumenbach,
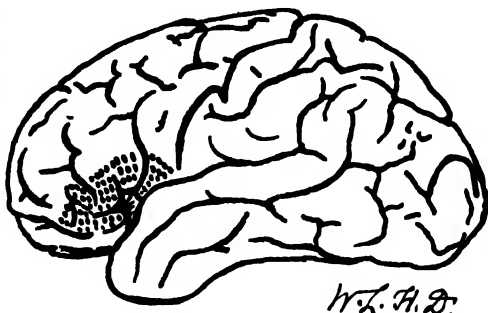
Fig. 6. Left cerebral hemisphere of an aboriginal native of Australia. "Broca's convolution" is indicated by the shading.

has been spoken of as distinct from that of Human Morphology, but it is important to notice that the newcomers in this field recognised that Craniology is to be regarded as essentially a branch of Human Morphology, and that only in this way can it lead to reliable results: the omission to recognise this important fact has led to many misconceptions and to the vain expenditure of much misdirected energy in Craniology.

But this does not complete the account of the extension of territory claimed by our subject. We must leave for the moment

Broca worked out an anatomical comparison (*Parallèle*, as it is termed by French writers) of Man and the Apes. Recognising the importance of the brain in the animal economy Broca devoted much time to its study. His contributions to

the subject of Aphasia, and his recognition of the localisation of the faculty of speech in the convolution which now bears his name (the inferior frontal convolution of the left cerebral hemisphere), are well known (cf. Fig. 6). And though his conclusions have not been altogether borne out in detail by the results of later workers, Broca's contributions to the morphology of the brain certainly place him among the foremost pioneers in that field.

Not the least of Broca's merits is his recognition of the necessity of accurate methods of comparison, and this led to his devising a multitude of delicate instruments of which the best known is perhaps the stereograph (cf. Fig. 7), a mechanical apparatus for tracing contours which can subsequently be superposed and accurately compared. Broca's extension of the use of "indices" in craniological studies,

Fig. 7. The stereograph of Broca: a mechanical device for producing rectilinear projection drawings of crania or similar objects. For further description see Chapter x.

a method due to the elder Retzius, is an important feature of his works, but is not a matter of such lasting or fundamental importance in regard to his scientific contributions as a whole.

the various problems grouped under the general heading of Morphology and turn to another aspect of the study of Man. Anthropology being now regarded as the Natural History of Man, it became necessary to investigate not only his bodily structure but his intellectual powers and their manifestations: not only these, but even the origins of human society, and of arts and sciences of whatever kind, were gradually added to the list, so that Anthropological literature now deals with a variety of subjects so diverse as the studies of languages, of the special senses in civilized and savage races, of decorative art, of the origins of religion, of picture-writing, of children's games, of keramics, of metallurgy, and of midwifery. In fact, Anthropology is no longer a single science but a group of these, and consequently, to use the simile so ably put forward by Professor Tylor, can be well compared to the frame used by mountaineers for the purpose of supporting a miscellaneous load. The convenience of the frame more than compensates for the slight additional weight imposed by it.

It is appropriate to remark in this connection that the theory of Evolution has proved to be of the utmost utility in the study, not of Animal Morphology alone, but of every one without exception of the above-mentioned subjects, widely different though they may at first sight appear to be. In every one without exception may be found numerous instances in which the doctrine of Evolution has given the clue to the interpretation of a series of observations, and has afforded such a demonstration of otherwise unsuspected relations between them as no other known principle could have possibly furnished[1].

The foregoing notes may serve to give an idea of the protean nature of Anthropology; a subject which the individual will strive in vain to grasp fully in the course of his natural lifetime. It is therefore necessary to limit one's efforts to a certain region or section, and the section which will be the subject of consideration in the following chapters is that to which reference has been already made, viz. the morphological aspect of Anthropology; incidentally, however, it will be necessary to refer to slightly different branches of the subject.

[1] For examples consult Haddon, *The Evolution of Decorative Art*; Balfour, *Evolution in Art*.

The following aims may therefore be proposed as falling within the scope of this enquiry. In the first place, the attempt must be made to realize the position occupied by Man in the animal kingdom: and secondly, enquiry must be made into the nature of the ancestors of Man. Finally, we may be in a position to discuss the question whether the series of animal forms which has produced Man has now reached its termination or not.

In connection with the first two questions, the following main paths lie open. It must be repeated that the study of Morphology by means of Comparative Anatomy is the first step in such an enquiry.

The second line of enquiry is closely allied to the preceding, and consists in the study of Morphology by means of Embryology[1].

A third line of research is nearly connected with the other two, this is the study of Variations, both of outward appearance and inward structure.

A fourth method, which has been found useful in other cases but is not specially applicable to that of Man, is the study of Geographical distribution. It will not be further mentioned at present.

A fifth method, more closely allied to the first (that of Comparative Morphology) than to any other, involves the investigation of the characters of such fossil animals as may be supposed to have figured in the ancestral history of Man and his nearest allies among the animals still in existence. This section of the science of Palaeontology claims much attention in the attempts to solve the problems of our subject.

Having discussed the general position of Man in Nature, it will be necessary to consider the various human races, and to enquire whether some of those races are to be regarded as morphologically inferior to others, and especially whether the races which are commonly accounted as lower in the scale of

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[1] Related to this second line of enquiry is the study of the post-natal stages of development, in other words, the study of child-life and of children. In accordance with the general rule that the individual reproduces in his life-history the successive stages (or the principal ones at least) by which his species attained its position in nature, it is argued that the immature human individual will afford some suggestions as to the nature of the latter stages of human evolution.

civilization and culture are also inferior in morphological status. Should this be established, it will next be necessary to ascertain whether such morphologically inferior forms can be considered as representatives of the generalized human ancestors. We thus enter on a division of the second great question, viz. that of the appearance and nature of the ancestral animal-forms which led up to Man.

The foregoing notes will give an idea of Human Morphology as studied from the standpoint of Anthropology; the immediate subject of consideration is thus seen to be the place of Man in the zoological series, or animal kingdom. Without entering into an elaborate exposition of various types of life, it will suffice to say that judged by his structure Man is undoubtedly a vertebrate animal of the class Mammalia. Starting from this point, it is proposed to briefly study the characteristics of Mammals so as to understand how it is that this statement as regards Man can be justified. The following chapter will accordingly deal with Mammalia in general.

SECTION A.

COMPARATIVE ANATOMY AND MORPHOLOGY
OF EUTHERIAN MAMMALS.

CHAPTER II.

THE MAMMALIA: AND THE APPLICATION OF THE METHODS
OF MORPHOLOGY TO THEIR CLASSIFICATION.

It is necessary at the outset to give a brief description of the animal forms with which we are chiefly concerned, and to treat of them in a methodical manner.

Man's nearest relations are members of a class of vertebrate animals called Mammalia. Of this class three sub-classes are recognised, and it must be noted that the members of two of these three sub-classes are comparatively few in number and not natives of Europe; an example of one of these sub-classes is the Australian spiny ant-eater, and the kangaroo is an example of the other. The third sub-class contains a larger number of animal forms, and to it belong all our indigenous mammals.

One can imagine several ways in which the various mammals might be grouped for purposes of description: for instance they might be arranged according to their geographical distribution, or else according to the nature of their food, or again according to their habits: and the first-mentioned means of distinction might be called a climatic criterion, which would for instance distinguish arctic animals from those living in tropical latitudes,

while the second means of distinction (diet) would be called a physiological criterion. Thus it is that we are compelled at the outset to state clearly the basis upon which we proceed in a classification. In the present case the basis is Morphology, and our criterion is the criterion of structure. In this classification, animals will be considered as more or less closely related, according as their structure is more or less similar in its details. ·It is necessary to enter into details, because the very fact of the name "vertebrate" being applicable to all the animals about to be considered, implies that they possess one general morphological character in common, and indeed that they are constructed upon a similar plan. Further, although this is an anticipation, it may be said that when the criterion of structure is employed, the determination of the relations of Man in the Class Mammalia is more easy than when other criteria are made use of. On this subject the verdict of Morphology is clear and unhesitating.

It is further to be noted that the most primitive morphological type of mammal is as a rule, though not always, the most simple; and the less primitive is often, though by no means always, the more complex in construction.

The comparative method of study is to be applied to all the mammalian forms, and when the test of Morphology is applied to Man himself it will be found as has been said that his relative position is well defined. This application of the principles of Morphology to the special case of Man constitutes the essence of Physical Anthropology.

In connection with what have just been referred to as the principles of Morphology, the following point is of interest and importance. It will be remembered that the vertebrate body is composed of a number of very different parts, and that although these are demonstrably similar to one another, inasmuch as they all possess cellular structure, yet the cells have undergone specialization in several different directions, with the consequent production of a number of tissues from which have been built up systems familiar to us as the skeletal system, digestive system, and so on. It is indeed an important consideration in Vertebrate Morphology, that specialization of primitively similar cells has occurred, resulting in the production

of tissues and systems. From the general consideration of the vertebrate body it is however necessary to pass to that of the several tissues and systems, and here it is that the point in question presents itself.

In the study of the morphology of the various systems, we find that each is constructed on a certain plan, so that each may be referred to a fundamental, primitive, or type-form. Thus the primitive forms of the central nervous system, or of the skeletal or arterial systems, are common expressions. Each system of a given animal reveals a more or less altered representation of that primitive form. Now the difficulty alluded to consists in the fact that in such a given instance (and this is especially true of Mammals), though each system will be found to represent a modified form of the primitive type, yet the amount of modification undergone is different for each system. Thus an animal may possess a nervous system of very primitive, i.e. slightly modified, form together with an extremely modified integumentary system. It follows therefore that in assigning a place in the classification to a given animal, attention must be paid to the morphology of each and every system, and a position must only be assigned to it after a final summary of all the evidence has been made. Thus an animal like the hedgehog presents us with the morphological combination of a brain of simple conformation, together with an integument of very modified character. Taking other morphological points in the anatomy of the hedgehog, the general balance of the summing up of evidence indicates that on the whole this is a little modified, i.e. a comparatively simply-constructed animal, which is the result one would have arrived at from the study of the brain alone, though opposed to the indication that would be afforded if the observation had been confined to the integument.

The disadvantage attendant on the employment of a single criterion, such as the conformation of a single organ or system, may be further illustrated by the example of the genitalia in Man. Judged by the single characteristic of the morphology of the genital organs, Man differs more widely from Woman than from an individual of his own sex in such a comparatively lowly form as a shrew-mouse. It follows therefore that in-

ferences from observations on various systems and organs must be introduced into what may be called the morphological balance sheet, due allowance being made for conditions ʻ determined by sex and by age.

The foregoing remarks will serve to indicate the importance of taking into consideration the evidence given by several systems and of summing up the results thus obtained.

It will be further seen that the determination of the value to be attached to the evidence from various systems is to a large extent a matter of agreement or convention. In returning to the subject of the Classification of Mammals[1], we must then first consider the combination of morphological characters which entitle the animal possessing them to be ranked as a mammal. In view of what has just been noted as regards the different systems, it will not be a matter of surprise that the characters selectedʼ are taken from several, and not all from any one system.

The Distinctive Characters, and the Classification of Mammals[2].

The Mammalia are air-breathing vertebrates, with warm blood, and with an epidermal covering in the form of hairs.

I.   The bodies of the vertebrae are in nearly all mammals ossified each from three independent centres, one of which developes into the centum proper, while the others give rise to two discs of bone—the epiphyses. Also characteristic of the spinal column of mammals are the discs of fibro-cartilage, termed intervertebral discs, which intervene between successive centra.

II.   The skull has two condyles for connection with the atlas, instead of the single condyle of the Sauropsida (Birds and Reptiles); and the lower jaw articulates with the skull in the squamosal region without the intermediation of the separate quadrate element always present in that position in Birds and Reptiles.

---

[1] Notice that the character, viz. the nutrition of the young by the secretion of milk-glands, which has given the Class its name, is not a morphological, but a physiological feature.

[2] Owing to the courtesy of authors and publishers, the classification of the Mammalia as given by Messrs Parker and Haswell in their *Text-book of Zoology*, Vol. II. (Macmillan), is here available.

.ch of the long bones of the limbs is composed (in the
ition) of a central part or shaft, and of terminal epi-
latter only becoming completely united with the shaft
ced stage. The ilio-sacral connection is pre-acetabular:
there is a cruro-tarsal joint.
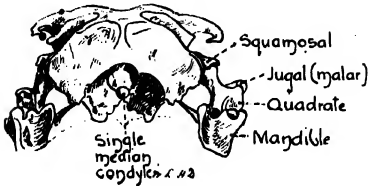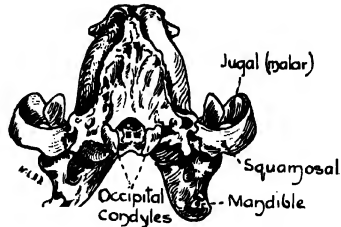
Fig. 8.   Fig. 9.

Fig. 8. Occipital view of the cranium of a Bird (Larus); to shew the single
median occipital condyle, and the intervention of the quadrate bone between the
mandible and the cranial wall.

Fig. 9. Occipital view of the cranium of a Dog; to shew the twin occipital con-
dyles, and the direct articulation of the mandible with the cranial wall, without the
intervention of a quadrate bone.

IV. In the Mammalian pectoral girdle, the coracoid of Birds and
Reptiles is usually represented only by a vestige or vestiges which
unite with the scapula in the adult. Figs. 10, 11, and 12.
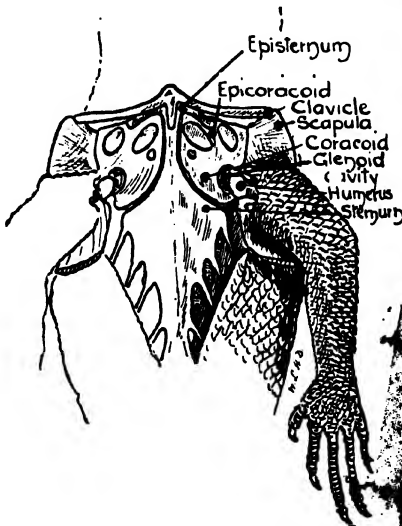
Fig. 10. Shoulder girdle of a Reptile (Iguana); to shew the elements of the
girdle in a comparatively undifferentiated condition.
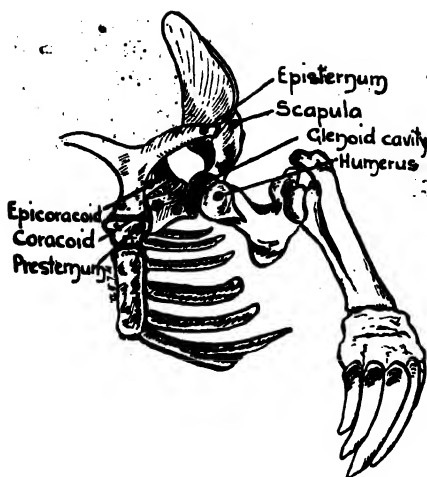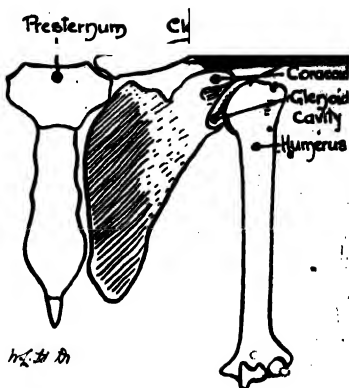
Fig. 11.   Fig. 12.

Fig. 11. Shoulder girdle of a Prototherian Mammal (Echidna) ; to be compared with Fig. 10. Several of the primitive constituent elements of the girdle are still distinct.

Fig. 12. Shoulder girdle of an Eutherian Mammal (Man) ; to shew the reduction in number of elements remaining distinct.

V.   Mammals are typically diphyodont, i.e. have two sets of teeth—a milk or deciduous set, and a permanent set: some are monophyodont, i.e. have only one set.   The teeth are thecodont, i.e. the base of each tooth is embedded in a distinct socket or alveolus in the substance of the bone of the jaw: and nearly always the teeth in different parts of the jaw are clearly distinguishable by differences of shape into incisors, canines, and grinding teeth, i.e. are heterodont ; in some instances the teeth are all alike (homodont).

VI.   A cloaca is absent, except in the Prototheria.

VII.   A moveable plate of cartilage—the epiglottis—represented only by a rudiment in some Amphibia and Sauropsida—overhangs the slit—commonly called glottis—leading from the pharynx into the cavity of the larynx.

VIII.   A partition of muscular fibres usually with a tendinous centre—the diaphragm—divides the cavity of the body into two

...the thorax—containing the heart and lungs, ...the abdomen—containing the greater part of the ...with its associated glands—the liver and pancreas ...nal and reproductive organs.

...lungs are freely suspended within the cavity of the thorax.

...The heart is completely divided into two halves—a right and ...—between which there is no aperture of communication. Each half consists of an auricle and a ventricle, opening into one another by a wider opening, guarded by a valve composed of three membranous cusps on the right side, two on the left. The right ventricle gives off the pulmonary artery; the left gives off the single aortic arch, which passes over to the left side, turning round the left bronchus in order to run backwards as the dorsal aorta: it therefore represents the left aortic arch of Reptiles.

...The blood is warm. The red blood corpuscles are non-nucleated and usually circular.

...The two cerebral hemispheres, in all but the Prototheria and Metatheria, are connected together by a band of transverse fibres—the corpus callosum—not represented in the lower vertebrates. The dorsal part of the mid-brain is divided into four optic lobes—the corpora quadrigemina. On the ventral side of the hind brain is a transverse band of fibres—the pons varolii—by which the lateral parts of the cerebellum are connected together.

...The ureters (except in the Prototheria) open into the bladder. Mammals are all, with the exception of the Monotremes, viviparous.

...The foetus is nourished before birth from the blood system of the parent through a special development of the foetal membranes and the lining membrane of the uterus, termed the placenta. After birth the young mammal is nourished for a longer or shorter time by the milk or secretion of the mammary glands of the parent.

...Such are the characteristics common to all mammals. The animals presenting these characters have been classified as follows.

CLASSIFICATION

CLASS MAMMALIA.

Sub-Class 1. Prototheria.
          Order Monotremata.

Sub-Class 2. Theria.

SECTION A. *Metatheria.*

Order 1. Polyprotodontia.
Order 2. Diprotodontia.

SECTION B. *Eutheria.*

Order 1. Edentata.
Order 2. Cetacea.
Order 3. Sirenia.
Order 4. Ungulata.
Order 5. Carnivora.
Order 6. Rodentia.
Order 7. Insectivora.
Order 8. Cheiroptera.
Order 9. Primates.

Without entering into a detailed description of the characters of the several Orders, it will suffice to enumerate those of the Sub-Classes and of the Sections.

SUB-CLASS I. PROTOTHERIA.

1. The vertebral centra lack epiphyses, or these are only imperfectly developed.

2. The bones of the skull coalesce early, by the obliteration of the sutures (the skull thus resembling that of birds).

3. A large coracoid, articulating with the sternum, is present.

4. A T-shaped episternum is present.

5. Two epi-pubic bones are present.

6. A cloaca is present, into which ureters and urinary bladder open separately.

7. The corpus callosum is not developed in the brain.

8. The oviducts are distinct throughout.

9. The mammary glands are devoid of teats.

10. The ova are meroblastic, and are discharged in an early stage of their development, enclosed in a tough shell.
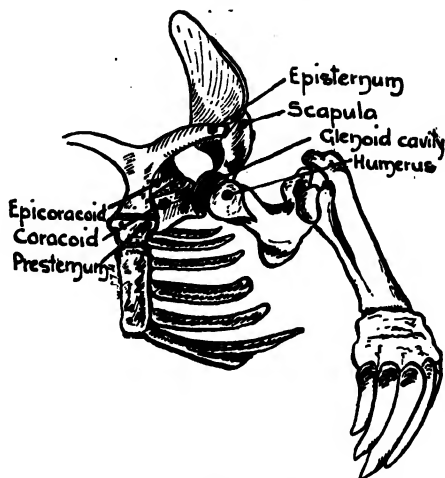
This Sub-class comprises a single living Order, the Monotremata,

Fig. 13. Shoulder girdle of a Prototherian Mammal (Echidna); to be compared with Fig. 10. Several of the primitive constituent elements of the girdle are still distinct.

including the Duck-bill or Platypus (Ornithorhynchus), and the Spiny Anteater (Echidna), together probably with an imperfectly known and extinct (Secondary and early Tertiary) Order, the Multi-tuberculata.

SUB-CLASS II.   THERIA.

1. The vertebral centra possess distinct epiphyses.

2. The skull bones do not in most cases completely coalesce, most of the sutures remaining distinguishable throughout life.

3. The coracoid is vestigial.

4. The episternum is incorporated in the substance of the presternum (Götte).

5. The cloaca is not present (Gadow restricts this statement to males).

6. The oviducts are united in a longer or shorter part of their course.

7. The mammary glands are provided with teats.

8. The ova (except in some members of Section A of the Theria) are holoblastic, and the early development of the young takes place in the uterus.

9. The epi-pubic bones and the corpus callosum are variable in their occurrence.

SUB-CLASS THERIA. SECTION A. METATHERIA OR MARSUPIALIA.

1. Theria, in which the young are born in a comparatively un-developed state, and are sheltered during their later development in an integumentary pouch, the marsupium.

2. In the skull, the tympanic cavity is partly bounded by the alisphenoid ; the jugal (malar) bone furnishes a contribution to the floor of the glenoid cavity.
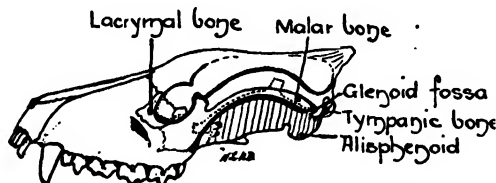
Fig. 14. Cranium of Sarcophilus, a Metatherian or Marsupial Mammal ; the shaded area denotes the extent of the alisphenoid bone along the cranial wall ; note the extent backwards of the malar bone, and the extent forwards of the lacrymal bone. Cf. Fig. 15.

3. Epi-pubic bones are present and well developed.

4. A single sphincter muscle surrounds both anus and uro-genital aperture.

5. The corpus callosum is absent.

6. The placenta, when present, is functional for only a short period.

The Metatheria (or Marsupialia) are divisible into two Orders, distinguished principally by the characters of their dentition, particularly of the incisor teeth. There is thus the Order Poly-protodontia, whose members have numerous (more than three on each side) incisor teeth. The Opossums belong to this Order. The second Order (Diprotodontia) possess not more and usually fewer than three incisor teeth on each side. The Kangaroos are examples of this Order.

SECTION B. EUTHERIA.

1. Theria having no marsupium. The young are nourished *in utero* for a considerable period, through the agency of a placenta.

2. In the skull, the alisphenoid does not contribute to the wall of the tympanic cavity; nor does the jugal (malar)(except in Hyracoidea and some Rodentia) contribute to the floor of the glenoid cavity.

3. No epi-pubic bones are present.

4. The anus and urogenital apertures are not surrounded by a common sphincter.

Fig. 15. Cranium of an Eutherian Mammal (Dog); for comparison with Fig. 14; note the smaller extent of the alisphenoid (shaded), the malar and lacrymal bones.

5. A corpus callosum is present.

The Eutheria can be divided into at least nine Orders distinguished by the various combinations of morphological characters enumerated in the following scheme.

Order 1. Eutheria, in which the teeth are absent in the adult or are imperfect; the sacral vertebrae are frequently in excess of the number usual in other orders. The coracoid process is usually relatively larger than in other Eutheria, and does not become completely fused with the scapula. The organisation of the brain is very variable. Edentata.

Order 2. Aquatic Eutheria with large head, fish-like body devoid of hairy covering, the pectoral limb paddle-like, the pelvic limbs absent, and with a horizontal caudal fin. The clavicles (collar bones) are absent, and the pelvis is vestigial. Teeth may be absent and replaced by sheets of baleen (or whalebone). The conformation of the nostrils and of the larynx is peculiar. Cetacea.

Order 3. Aquatic Eutheria with moderate-sized head, with porpoise-like body covered with a scattered covering of hairs : the pectoral limbs are paddle-like, the pelvic limbs absent. The clavicles are absent and the pelvis is vestigial. Teeth are present, and the palate bears rugose horny plates. The larynx is not modified as in the Cetacea. Sirenia.

Order 4. Terrestrial, chiefly herbivorous Eutheria, with hairy covering abundant or scanty ; the terminal phalanges of the digits, upon which the weight of the body usually falls, nearly always invested with solid horny hoofs. The clavicle is absent. The teeth are heterodont and diphyodont; the scaphoid and lunar bones of the carpus (wrist) are always distinct. The digits are often reduced in number. Ungulata.

Order 5. Eutheria, chiefly carnivorous, with furry integument : digits in manus and pes never less than four, and all provided with claws more or less retractile. The clavicle is variable in its presence, but it is never complete. The teeth are heterodont and diphyodont. The scaphoid and lunar elements of the carpus (wrist) are always united; the brain usually highly developed. Carnivora.

Order 6. Vegetable-feeding Eutheria, mostly small in bulk, with furry or spiny integument, clawed digits and usually plantigrade limbs. The dentition is heterodont and diphyodont, and the form of the incisors is chisel-like : these teeth grow from persistent pulps. Rodentia.

Order 7. Insectivorous Eutheria with nose usually prolonged into a short soft muzzle ; with furry or spiny integument, clawed digits, and usually pentadactyle plantigrade limbs. Clavicles are present. The dentition is heterodont and diphyodont, and the molars have pointed cusps : incisors are never fewer than two in the lower jaw on each side. The brain is very simple in conformation. Insectivora.

Order 8. Eutheria in which the pectoral limbs are modified to form wings, the bones being greatly elongated so as to support a broad web of skin extending to the hind limbs posteriorly. The ulna is vestigial, the clavicles well developed. Cheiroptera.

Order 9. Eutheria with prehensile limbs (adapted to arboreal life), the thumb and great toe being more or less completely opposable to the other digits. The digits are nearly always five in number, and are provided usually with flat nails: the clavicles are well developed. The brain is variable, but may present high conditions of development of the cerebral hemispheres. Primates.

It is to be remarked that although numbered from 1 to 9, it does not follow that this arrangement places the various Orders in sequence according to their morphological status. It is an extremely difficult question to decide which is to be regarded as occupying the highest morphological place: nor are the relations between the various Orders very clear. The Insectivora have primitive characters. The Edentata (Anteaters, Armadillos and the Earth-pig) seem to stand apart and in a somewhat inferior position[1]. The Rodentia are also to a considerable extent isolated. On the other hand the Cetacea and Carnivora seem distantly connected, as do the Sirenia (Manatee and Dugong) and Ungulata: while the Insectivora, Cheiroptera, and Primates shew marked signs of affinity with one another[2].

The foregoing classification is found to be generally useful, and applicable to the great majority of mammals. It cannot be too clearly stated that it is after all largely conventional, although based on the observed facts of animal structure; but the advantage conferred by the mere fact that we can classify mammals is great, for it enables us to compare their forms and characters much more easily than if they were not susceptible to reduction to such order. But like conventional systems of other kinds, it has its limits; in other words, it does not apply to every animal. For there are animals which, when examined in the light of morphology, and the morphological summary is made, prove hard to fit into this classification. When we meet with such an instance, we should therefore remember that it does not prove that the classification is bad or deceptive, but it shews rather that

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[1] Judged by the single criterion of brain-formation, this judgment appears from the researches of Elliott Smith (*Linn. Trans.* VII, Ser. 2) to need revision; for the brain in some Edentata is more highly developed than in certain mammals commonly regarded as their superiors.

[2] Cf. Flower, *Osteology of the Mammalia.*

animals have been evolved without regard to any such conventional system of classification. Indeed on the hypothesis that the method of the origin of species is an evolution, it follows quite naturally that animal forms should merge into one another by imperceptible gradations, and that classification, or grouping in classes, is actually only possible in view of the fact that large numbers of animal forms have failed to maintain their places in the struggle for existence. Had they not failed, it is possible to imagine a demonstration-series of animal forms ranging from the Amoeba to Man without any break or interruption. As it is, the series is discontinuous and incomplete, and the systematist seizes on isolated groups, giving each a special name in his classification. And what of the animals between these groups? It may be repeated that some, having failed in the struggle for existence, can only be directly known to us by such of their remains (and they are not many) as have been preserved in a fossil form. The skeletal parts only are as a rule thus preserved, and this shews incidentally the importance of osteology in morphological study. These are the animal "links" which have been referred to as "missing." A few intermediate forms have persisted down to our time, and these are the animals to which it is hard to assign a definite position in the system of classification which has been described.

It should be further remembered that though in an uniform linear chain all the links are of equal value, yet in the variable series of animals known to us, such isolated links may be of very different significance, the difference depending on the groups of animals connected by the link, whether the latter be known in the fossil or recent state. Moreover the metaphor of a linear chain is not so exact as that of a sheet of chain-armour in which a single link may bring three or four other links into mutual relation.

To take some examples, there may be cited such animals as the Archaeopteryx, a form which suggests a link between the *Class* of Birds and the *Class* Reptilia: the Galeopithecus volans, which occupies a corresponding position, but merely with regard to *Orders* (viz. the Insectivora, Cheiroptera and Primates) of the Class Mammalia: the Cynopithecus monkey of Celebes, which

connects the *Genus* Macacus with the *Genus* Cynocephalus, within the limits of the Order Primates. Inasmuch, however, as we are dealing here principally with animals of the Class Mammalia, it follows that the links with which we are concerned will be comparable in point of importance with the two latter examples, rather than with the first-mentioned instance.

In conclusion, the cases of such intermediate forms offer excellent opportunities of employing and testing the principles of morphological examination upon which is based the system of classification here set forth.

CHAPTER III.

THE MEMBERS OF THE MAMMALIAN ORDER PRIMATES.

In the foregoing chapter the relative positions of the various Orders of the Class Mammalia were briefly reviewed from the standpoint of evolution. If it be assumed that the typical or representative mammal has during the period of its evolution passed through vertebrate stages corresponding respectively to those of the Fish, Amphibian, and Reptile, it seems intelligible that in some mammals a greater number of ancestral characters occur than in others. Such mammals as possess a greater number of such reminiscent characters should be regarded as primitive, while others should be described as less primitive, or more highly evolved.

. From this standpoint there is much evidence for assigning the lowest place among the Mammalia to the Order Monotremata composing the Sub-Class Prototheria. In series above these, and consequently less primitive in their degree of evolution, are the Metatheria, among which the Order Polyprotodontia are more primitive than the Diprotodontia. Above the Metatheria[1] come the Eutheria, consisting as has been already remarked of some nine Orders.

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[1] The fact must however not be overlooked, that while Prototheria and Metatheria may thus be regarded as primitively and slightly evolved, there are not lacking those who would regard some of their features as the result of extreme specialisation and even degeneracy. For the brain, at least, the statements made in the text appear to hold good (cf. Elliott Smith, "Origin of the Corpus Callosum," *Linn. Trans.* VII, Ser. 2), and to the brain-evidence much weight must admittedly be attached.

With regard to the grouping of the several Orders of the Section Eutheria, several difficulties present themselves. On the whole, the Edentata and the Insectivora are the most primitive of the Eutherian mammals: and it is remarkable that the Insectivora are nearly approached by some members at least of the Order Primates, to which, as will be presently shewn, the study of Vertebrate Morphology assigns Man. But it seems to be impossible to group the Eutherian Orders satisfactorily in an evolutionary sequence, nor is it even possible to arrange subclasses or sections in such a linear series as shall be beyond the reach of criticism: that this must be so will appear as a necessary sequence of the arbitrary nature of the method of classification adopted as has been already explained[1]. Nevertheless the general relations of the various subdivisions may be represented graphically as was done by the late Sir William Flower in a diagram published in his work on *Osteology of the Mammalia* (*f.* 1), which may be supplemented by the diagram which follows (Fig. 16).

It will no doubt be noticed that the expression "stage of" such and such a generalised animal form is employed in this diagram. It will therefore not be out of place to indicate that on the hypothesis of evolution a given animal of the Mammalian Class should shew, in its ancestral history, forerunners more closely resembling reptiles, amphibia, or fishes. Even so, however, such animals would possess the characteristics *not* of any particular reptile, or amphibian, or fish known to modern zoologists, but rather the characteristics of the generalised animals whence all the various forms of reptiles, amphibia, or fishes respectively have sprung. These considerations have the effect of rendering the construction of an accurate diagram exceedingly difficult, and that now offered is not to be regarded as expressing all the facts of the case, but as the most convenient form of exposition available.

Some of the evidence for the assignation of the Monotremata to a lowly position among Mammalia has been given in Note II. and may now be recapitulated. It comprised the following statements descriptive of the morphological anatomy of the Monotremes.

Stage of Primate mammal (Order Primates).

Stage of Insectivorous mammal (Order Insectivora).

Stage of generalised Eutherian mammal (Section Eutheria).

Stage of generalised Metatherian mammal (Section Metatheria).

Stage of generalised Therian mammal (Sub-Class Theria).

Stage of generalised Prototherian mammal (Sub-Class Prototheria).

Stage of generalised Mammal (Class Mammalia).

Specialised Reptiles.

Birds.

Stage of generalised Reptile (Class Reptilia).

Amphibia

Stage of generalised Amphibian (Class Amphibia).

Stage of generalised Fish (Class Pisces).

Fig. 16.

(1)   The possession of oviducts which are distinct from each other throughout their course.

(2)   The possession of a cloaca.

(3)   The lack of vertebral epiphysial plates.

(4)   The structure of the shoulder girdle (full development of the several elements).

(5)   The production of meroblastic ova,

as well as the physiological characteristic of being oviparous.

Turning now to the Metatheria (Marsupialia), the evidence for the lowlier status of these as compared with the Eutherian mammals depends chiefly on the conformation of the brain, which lacks the great cerebral commissure known as the corpus callosum; herein the brains of Metatheria (Marsupialia) resemble those of Monotremata and Reptilia, while differing from those of Eutheria. The mode of nutrition of the embryo of Metatheria is considered by some to indicate the same primitive position as compared with Eutheria, but this is a subject upon which much more light must be shed before a final verdict can be pronounced.

Within the range of the Eutherian Orders, the Insectivora are unanimously regarded as meriting a most lowly position, in any scheme of classification by which the more primitive and the less highly evolved are compared. The evidence for this conclusion may be summed up as follows:

(1)   The number and characters of the teeth.

(2)   The characters of the cerebral hemispheres.

(3)   The mode of development of the amnion in the embryo.

(4)   The arrangement of the somatic musculature.

It is perhaps not out of place to mention that a particular insectivorous mammal, the so-called Gymnura rafflesii of the East Indies, has retained in its anatomical structure the greatest number of such characters as confer upon a mammal the distinction of occupying a low position in the scale, and for this reason the Gymnura is regarded as the best living representative of a generalised Eutherian mammal.

Passing to the Order of the Primates, it will be necessary to set forth in detail the general morphological characteristics of the Order as well as those of its several subdivisions.

The Order Primates is subdivided into Sub-Orders, these again into Families, and these successively into Genera and Species in the following way (cf. Flower and Lydekker, *Mammals*).

Order
PRIMATES
{
  Sub-Order
  LEMUROIDEA [1]
  {
    Family Lemuridae (several genera and species).
    Family Tarsiidae (a single species and genus).
    Family Cheiromyidae (a single species and genus).
  }

  Sub-Order
  ANTHROPOIDEA [2]
  {
    Family Hapalidae (one genus, several species).
    Family Cebidae (several genera and species).
    Family Cercopithecidae   „   „   „.
    Family Simiidae   „   „   „   .
    (? *Family* Pithecanthropidae) (? one genus and species).
  }

  Family Hominidae (one genus, and one or at most two species).
}

It is to be noticed that the Family Pithecanthropidae is a provisional one, the evidence for its existence in former times resting on the morphological characters of a single calvaria, a femur, and three teeth discovered by Eugene Dubois in a pliocene deposit in Java. The recent work of Schwalbe (Strassburg) on the fossil man of the Neanderthal near Düsseldorf (Germany) seems to leave little room for escaping the conclusion that Homo neanderthalensis is to be distinguished specifically from Homo sapiens.

The ensuing notes on the characters of the Order, Sub-Orders and Families of the Primates are abstracted (with permission) from the work of Parker and Haswell on Zoology. References to Gadow's work on Classification will also be found.

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[1] Much diversity of opinion regarding the retention of this division into Sub-Orders now exists (cf. Elliott Smith, *Linn. Trans.* vol. VIII, part 10, page 417, for recent literature and comments).

[2] As an example of the diversity of modes of classification that given in the text may be compared with that given by Cope (*Syllabus*, Philadelphia, p. 120).

I.   Order Primates: Eutheria, nearly all of which are adapted to an arboreal life, the limbs being prehensile owing to the pollex and hallux being more or less completely opposable to the other digits.

Dentition: heterodont; diphyodont; incisor teeth two in number on each side above and below: the Aye-Aye (Cheiromys) is the sole exception to this rule.

Digits: are, in nearly all, five in number, and are provided with flat nails both in manus and pes: the pollex and hallux are opposable.

Forearm: the ulna and radius are separate (i.e. not ankylosed as in many Eutheria) and well developed.

Orbit: surrounded by a bony ring.

Clavicles: well developed.

Entepicondylar foramen: abnormal (Parker and Haswell say absent).

Third trochanter of femur: abnormal (Parker and Haswell say absent).

Stomach: simple in most instances.

Testes: descend into a scrotum.

Mammae: usually two in number, and thoracic in position.

Placenta: variable (diffuse or meta-discoidal).

Order.   Taxeopoda.
Sub-Orders:
  I.   No clavicle   (1)   Condylarthra,
                       (2)   Litopterna,
                       (3)   Hyracoidea.
  II.   Clavicles present.
    (*a*)   Incisors growing from persistent pulps:
        anapophyses present................. Daubentonioidea.
    (*b*)   Incisors with closed roots:
        anapophyses present................. Quadrumana.
    (*c*)   Incisors with closed roots:
        no anapophyses present .... Anthropomorpha.

Compare this with Herluf Winge's Classification (in *Archiv für Anthropologie*, 1895), and note the comparative simplicity of criteria employed, when fossil forms only are dealt with.

SUB-ORDER.

LEMUROIDEA.

Ape-like Primates, nocturnal in habit, and of comparatively low organisation.   (Cf. Fig. 17.)

Teeth: dental formula

i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{3}{3}$; m, $\frac{3}{3}$;

the incisor teeth are widely separate in most cases.

Digits: of fore and hind limbs bear flat nails except the second digit of the hind limb, which bears a claw.   Both pollex and hallux are opposable.

Orbit: surrounded by a bony ring.   (Cf. Fig. 18.)

Lacrymal foramen : external to orbit.

Fig. 17.   General external appearance of a Lemur.
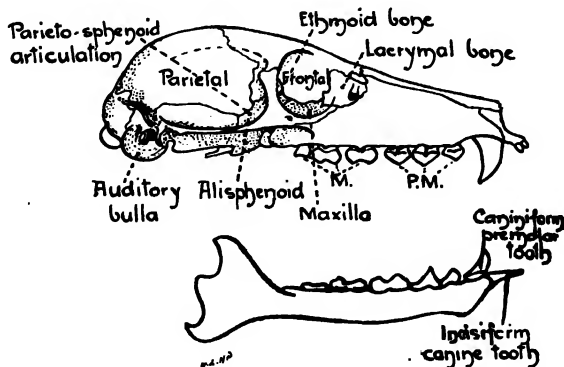
Fig. 18.   Cranium, with mandible, of Lemur varius ; note the auditory bulla, the articulation of parietal and alisphenoid bones, the facial extension of the lacrymal bone (cf. Fig. 12), the articulation of the frontal bone and maxilla behind the lacrymal bone, the small forward projection of the orbital plate of the ethmoid bone, the number of teeth, the small size of the upper and the great projection of the lower incisor teeth.   In the mandible, the canine-like tooth is a pre-molar by position, and the canine tooth is incisiform.

Colon: "bent on a bight" in its transverse portion. (Cf. Fig. 19.)

Cerebral hemispheres: feebly convoluted and not prolonged far backwards over cerebellum (Fig. 20): rhinencephalon relatively well-developed.

Mammae: two in number, thoracic in position; they may be supplemented by an abdominal pair.

Uterus: bi-cornuate.

Placenta: diffuse.

Hyoid bone: anterior larger than posterior cornu.

The Sub-Order Lemuroidea comprises the true Lemurs (Family Lemuridae), so called from their ghost-like appearance at night. Geographically, their distribution is almost entirely confined to the island of Madagascar, in which they have found

Fig. 19. Part of the alimentary canal of a Lemur: note the curiously contorted colon, and the enormous appendix caeci.

congenial surroundings; and of that local fauna they are very characteristic. A few examples occur in Africa and Asia. Fossil representatives occur, not in Madagascar only, but also in Europe and in North America.

· Besides the Lemuridae, two other animals are placed in this Sub-Order. These are (a) the Tarsius spectrum, an Asiatic animal, and (b) the Aye-Aye, Cheiromys, or Daubentonia madagascariensis, an inhabitant, as its name indicates, of Madagascar. These two animals are so peculiar that each is assigned to a separate family of which it constitutes the sole living genus and species. Tarsius spectrum differs from all other Lemuroidea (while it agrees with
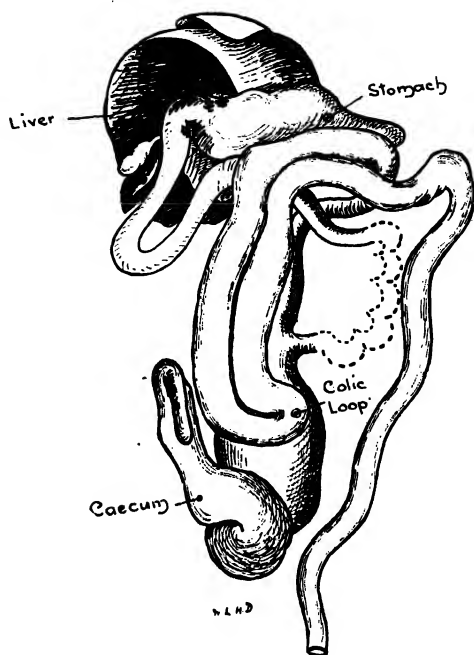
the Anthropoidea), in the possession of a discoid placenta. Its nearest ally is a fossil form occurring in North America. (Anaptomorphus. Cf. Chap. XVI.)

The Aye-Aye has no known fossil representative or near relation. It was thought at first to be a sort of arboreal rodent, for its incisor teeth are so modified as to reproduce the rodent type. When however the general morphology of the Aye-Aye became known, the summary of evidence did not support the indication afforded by its incisor teeth, but assigned to it the place in the classification which it now occupies.
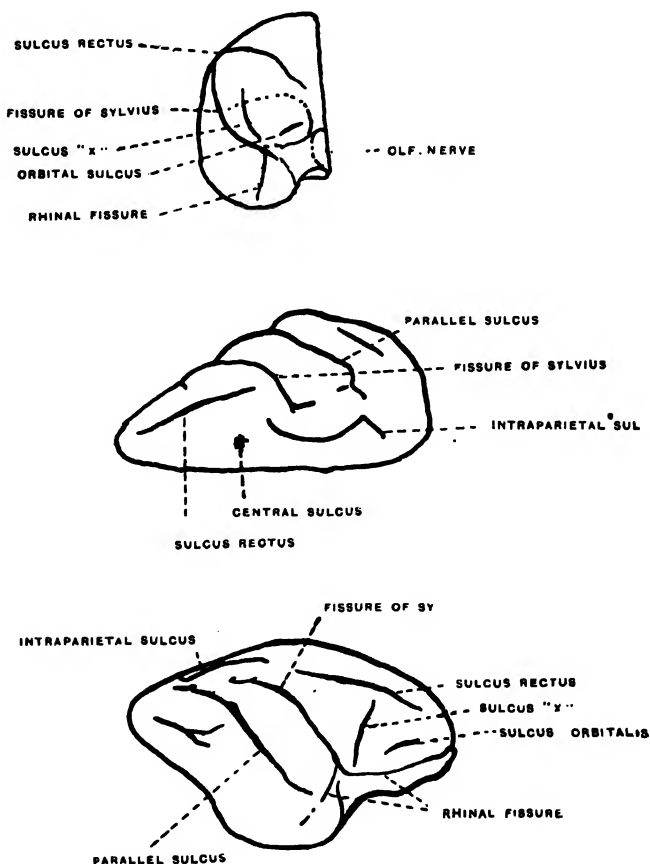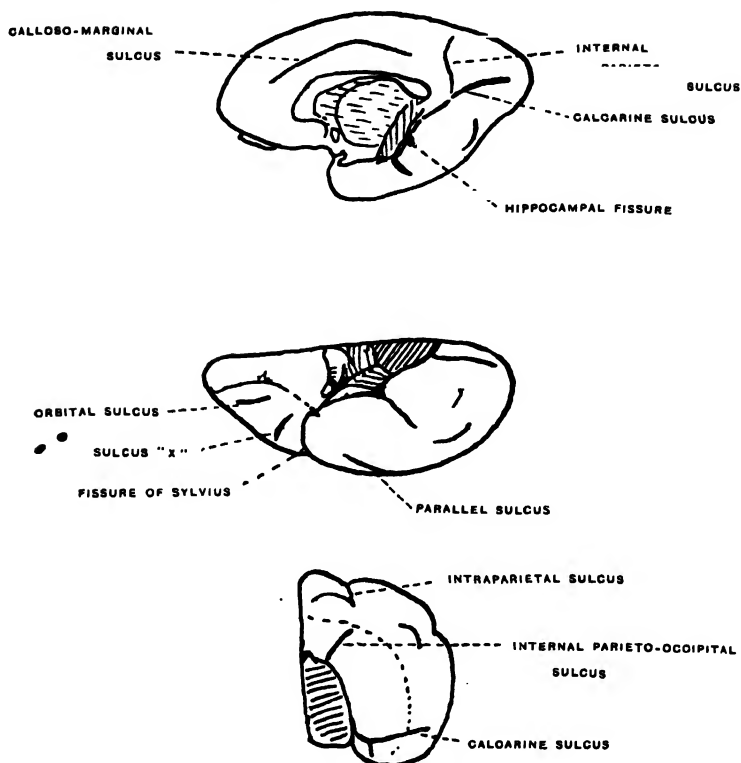
Fig. 20.   Six views of the right cerebral hemisphere of a Lemur : the first view is the frontal or anterior aspect ; then follow in turn the vertical, lateral, mesial, basal and occipital aspects : note the large size of the olfactory nerve, and the paucity of cerebral convolutions in comparison with the human cerebrum.

SUB-ORDER.

ANTHROPOIDEA.

Most highly organised Primates, chiefly modified for and adapted to an arboreal mode of life.

Teeth: the median incisor teeth are in contact with one another.

Digits : these are provided with flat nails (except in the Hapalidae).

Pollex : in a few instances is rudimentary or absent, in most it is well developed.

Orbit: the post-orbital boundary is a bony wall extending inwards from the post-orbital ring, and separating the orbit from the temporal fossa. (Cf. Fig. 21.)
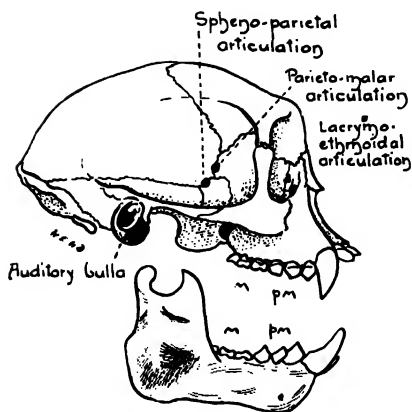
Fig. 21.
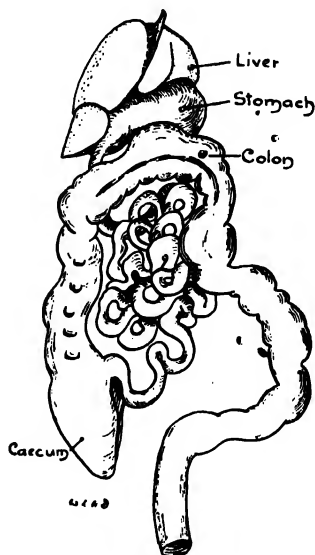
Fig. 22.

Fig. 21.   Cranium, with mandible, of Cebus capucinus (Cebidae).   Note the auditory bulla, and shallow auditory passage; the spheno-parietal and lacrymo-ethmoidal articulations, the latter suture being marked by a small circle; three molar teeth are seen in each jaw.

Fig. 22.   Part of the alimentary canal of a Cercopithecus monkey (Cercopithecidae): note the lack of contortion in the colon, and the absence of an appendix caeci.

Lacrymal foramen: this is situated within the orbital margin.

Colon: not looped as in Lemuroidea. (Cf. Fig. 22 with Fig. 19.)

Brain: cerebral hemispheres much convoluted and prolonged backwards to cover the cerebellum to a considerable extent (Figs. 23, 24, 25 and 34): rhinencephalon much reduced.

Mammae: two in number and thoracic in position.

Uterus: this has no cornua properly so called: Fallopian tubes spring directly from the body of the uterus.

Placenta: this is deciduate and meta-discoidal.

Hyoid bone: the posterior cornu exceeds the anterior cornu in size.
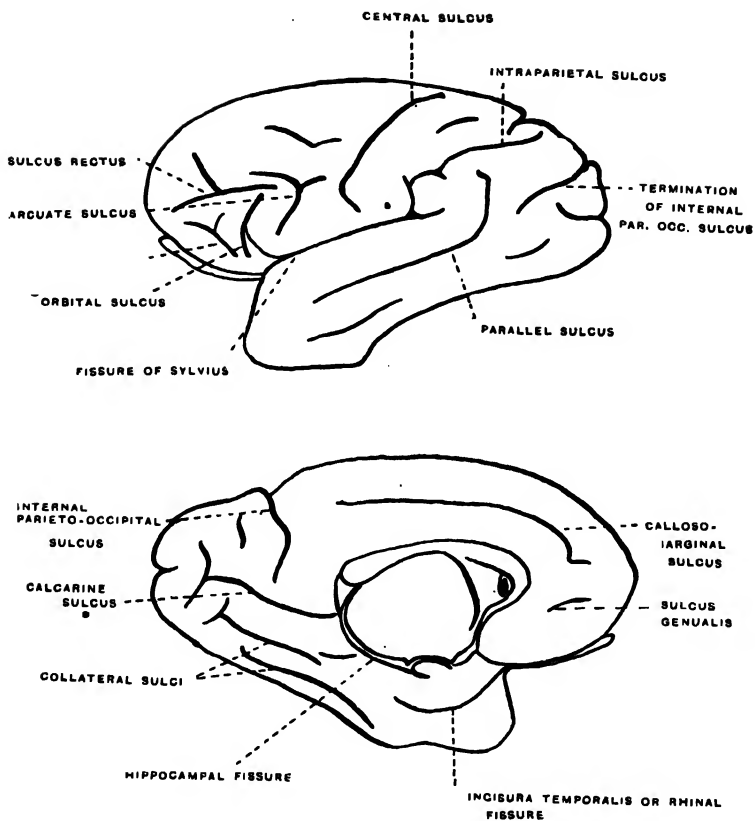
Fig. 23.   The left cerebral hemisphere of an American (Platyrrhine) ape, Ateles variegatus : the lateral and mesial aspects of the hemisphere are shewn.
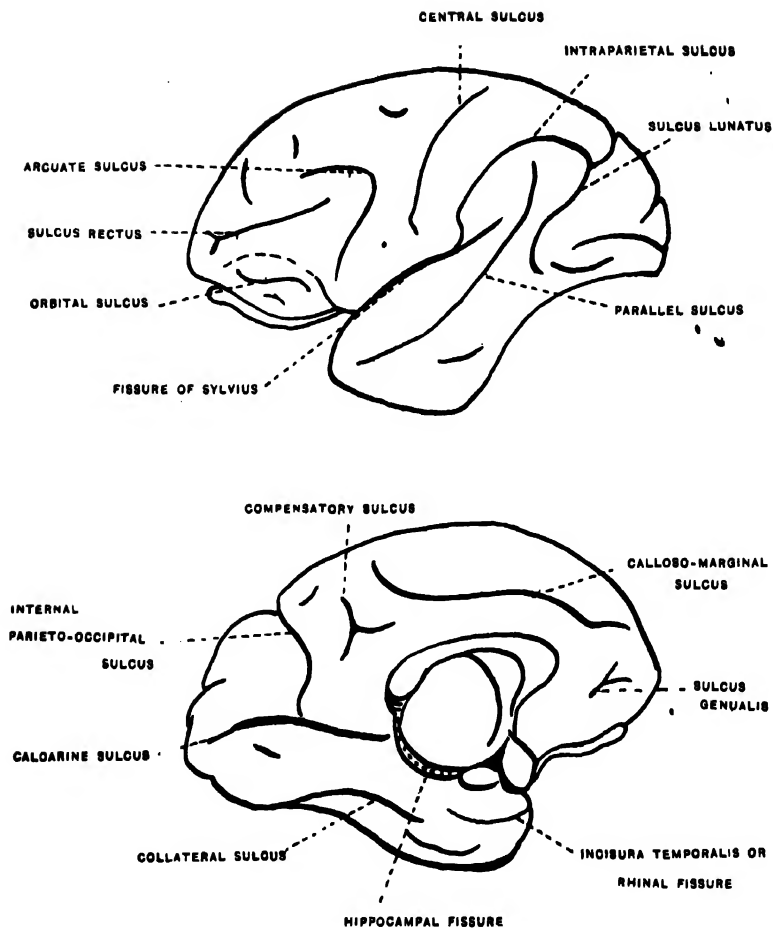
Fig. 24. The left cerebral hemisphere of a Nasalis monkey (Cercopithecidae): the lateral and mesial aspects are shewn. (Hose Donation II. Mus. Anat. Cant.)
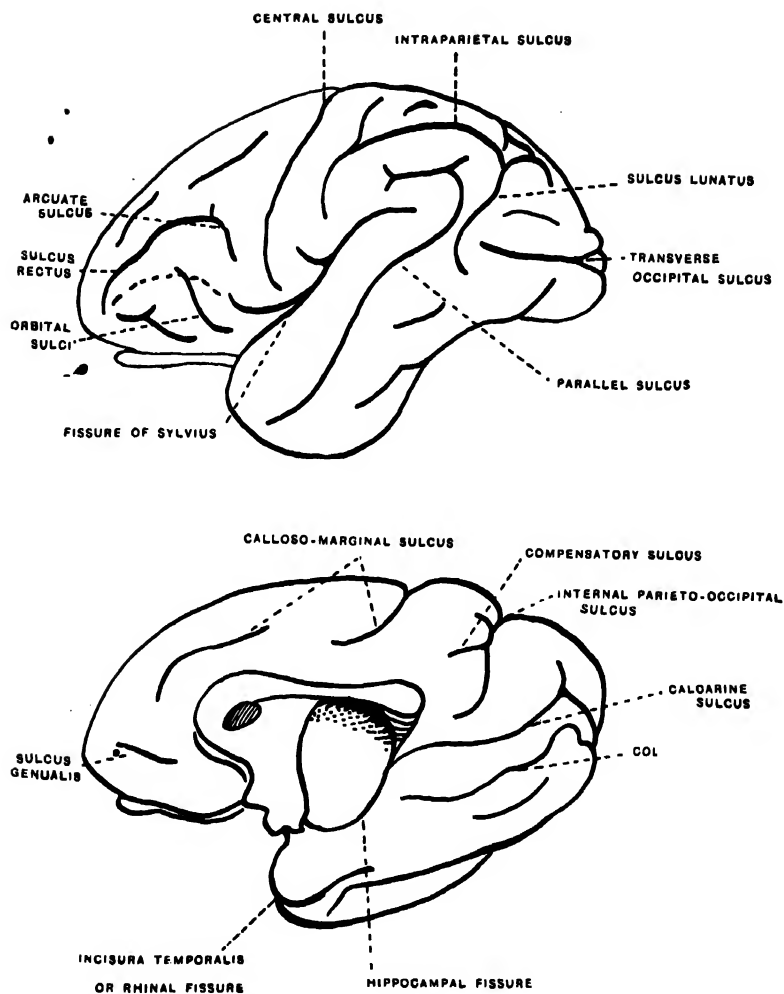
Fig. 25. The cerebral hemispheres of a Gibbon (Simiidae): the lateral and mesial aspects are shewn. (Hose Donation II. Mus. Anat. Cant.)

Family I.　Hapalidae[1].

Dental formula: i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{3}{3}$; m, $\frac{2}{2} = 32$.

Pollex: not opposable.

Digits: bear claws, no nails: the hallux is an exception to this rule.

Cheek pouches: not developed.

Ischial callosities: not developed.

External auditory meatus: not prolonged into an osseous tube. (Cf. Fig. 26.)
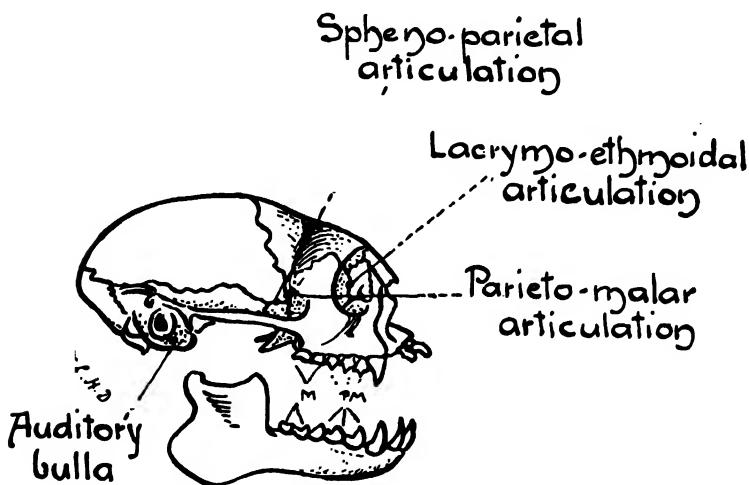
Fig. 26.　Cranium, with mandible, of Hapale jacchus (Hapalidae). Note the auditory bulla, the spheno-parietal articulation and in the orbit the lacrymo-ethmoidal articulation; two molar teeth are seen in each jaw, and the incisor teeth project strongly.

Tail: non-prehensile.

Nasal septum: wide (Platyrrhine).

The foregoing family includes the Marmosets.

Family II.　Cebidae[2].

Dental formula: i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{3}{3}$; m, $\frac{3}{3} = 36$.

[1] (Hapale: from a Greek word indicative either of minute size, or docile temperament.)

[2] (Cebus: the Arabic word for ape.)

Pollex: not opposable, in some instances rudimentary or absent.

Digits: all have flat nails.

Cheek pouches: not developed.

Ischial callosities: not developed.

External auditory meatus as in Hapalidae (cf. Figs. 21 and 26).

Tail: sometimes prehensile.

Nasal septum broad (Platyrrhine).

This family includes among others the Howling Monkey (Mycetes), Squirrel Monkey (Chrysothrix), Spider Monkey (Ateles), and Capuchin Monkey (Cebus).

It should be particularly noted that members of the two preceding families (Hapalidae and Cebidae) agree in the possession of a wide septum and space between the nostrils. They are for this reason called Platyrrhine Monkeys. Besides this characteristic, other morphological features distinguish the Platyrrhine apes from the other Anthropoidea, which from the possession of a narrow intra-narial space and consequent downwardly directed nases are called Catarrhine. In Craniology the terms Platyrrhine and Catarrhine are also used, but in this study they refer to the proportions of the apertura pyriformis nasi of the skull, and not to the intra-narial space of the face.

Family III. Cercopithecidae[1]. (Cf. Fig. 27.)

Dental formula: i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{2}{2}$; m, $\frac{3}{3} = 32$.

Pollex: opposable, in the genus Colobus not developed at all.

Cheek pouches: developed in many cases.

Ischial callosities: developed to a high degree.

External auditory meatus: guarded by an osseous tube formed by the tympanic bone. (Cf. Fig. 28.)

Tail: non-prehensile.

Nasal septum: narrow, the nostrils close together in consequence.

Sternum: narrow and rod-like.

Caecum: has no vermiform appendix.

This family comprises the Baboons (Papio or Cynocephalus), the Macaques (Macacus), the Cercopitheci, Semnopitheci, &c.

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[1] (Cercopithecus: a tailed ape.)

Fig. 27.   An adult male Nasalis or Proboscis monkey; a variety of Semno-
pithecus (Cercopithecidae) from Borneo. (Hose Donation, No. II. Mus. Anat.
Cant.)
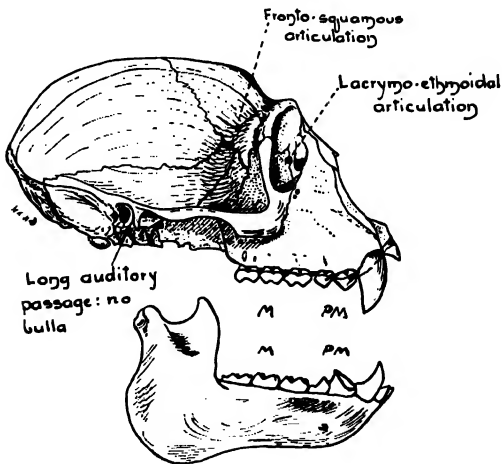
Fig. 28.   Cranium, with mandible, of a Macacus monkey (Cercopithecidae) ; note
the absence of an auditory bulla ; the substitution of fronto-squamous and fronto-
maxillary for spheno-parietal and lacrymo-ethmoidal articulations : note also the
number of teeth, and compare with Figs. 21 and 26.

Family IV.   Simiidae[1].   (Cf. Figs. 29, 30, 31.)
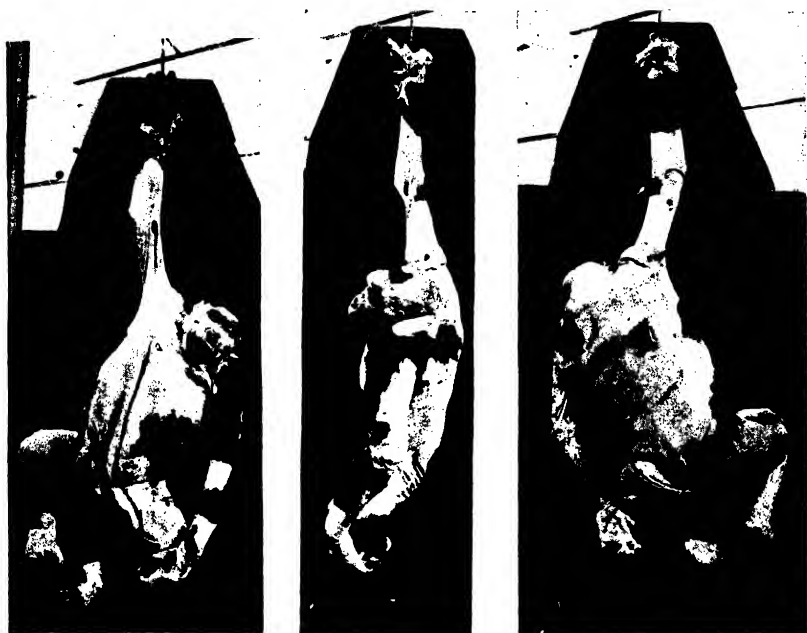
Fig. 29.   Fig. 30.   Fig. 31.

Fig. 29. Adult male Gorilla (Simiidae); the hair has been lost owing to inadequate preservation in alcohol. (Holt Donation, Mus. Anat. Cant.)

Figs. 30 and 31.   Other views of the same specimen.

Dental formula: as in the preceding family, viz.:

$$i, \tfrac{2}{2}; \ c, \tfrac{1}{1}; \ pm, \tfrac{2}{2}; \ m, \tfrac{3}{3} = 32.$$

Pollex: opposable.

Ischial callosities: found in one genus only, viz. Hylobates, the Gibbons.

External auditory meatus: an osseous tube, as in Family III. (Cf. Figs. 32, 33.)

Tail: not developed externally.

[1] (Simia : exact meaning doubtful; either "flat-nosed" or "mimic.")
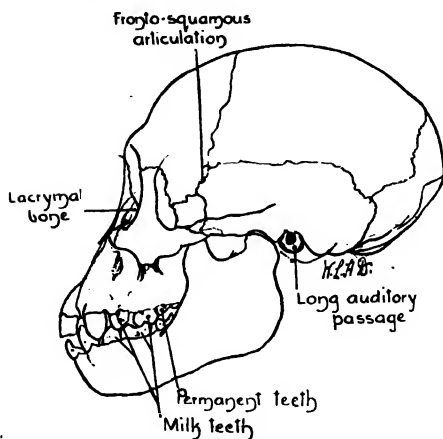
Fig. 32. Cranium, with mandible, of a young Gorilla (Simiidae) ; the first tooth of the permanent set has appeared (permanent molar tooth). Note, in contrast to Fig. 33, the comparatively large brain-case. There is no auditory bulla : the auditory passage is long, but not so long as in adults : there are fronto-squamous and fronto-maxillary articulations. Osseous ridges and crests are still undeveloped.
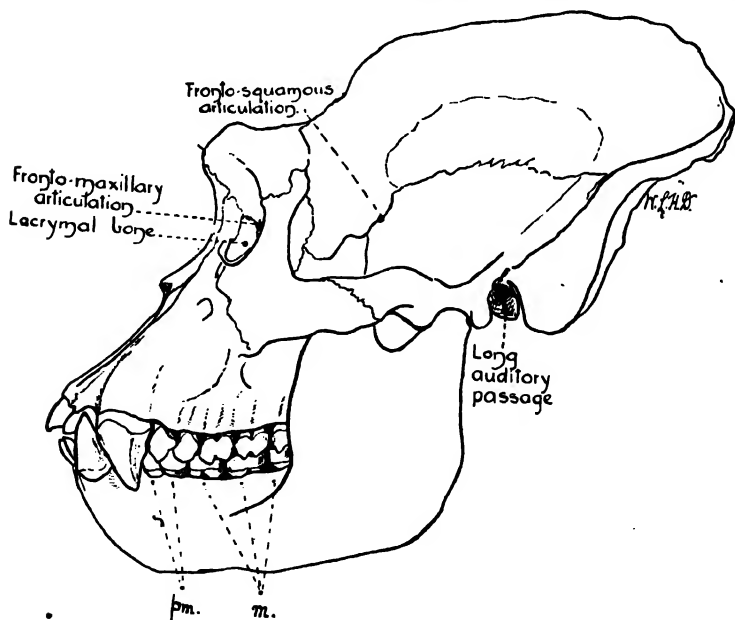
Fig. 33. Cranium, with mandible, of an adult Gorilla (Simiidae) : note the absence of an auditory bulla, the presence of great bony crests; and of fronto-squamous and fronto-maxillary articulations (the latter within the orbit in place of a lacrymo-ethmoidal junction). The canine teeth are enormously developed in the male sex.

Nasal septum: as in Family III.

Sternum: flat (lati-sternal type).

Caecum: vermiform appendix present.

Os centrale carpi: sometimes united with the os radiale carpi to form the scaphoid bone.
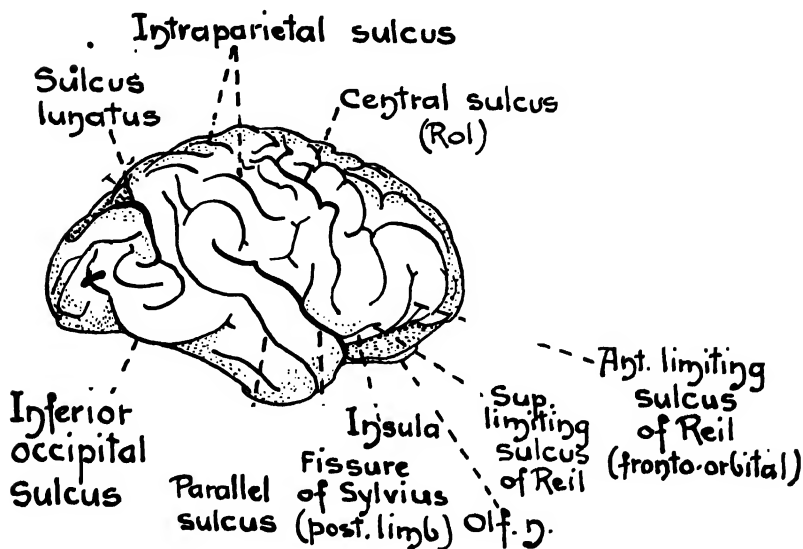
Fig. 34.   Lateral aspect of the right cerebral hemisphere of a young Gorilla (Simiidae). The olfactory nerves are attenuated in point of size: the cerebral surface is much more convoluted than in the preceding examples and recalls the appearance of the human cerebrum.   Cf. with Figs. 20, 23, 24, 25, and p. 38.

This family includes the Gibbons (Hylobates), Orang-utans (Simia), Chimpanzees and Gorillas (Anthropopithecus niger and gorilla).

Family V.   Hominidae.

The main characters conform so exactly to those of the preceding family that recapitulation is unnecessary. The Hominidae are however distinguished from the Simiidae by several morphological characteristics of which the following are the most important.

Hallux not opposable.

Pelvic limbs much longer and bulkier than the pectoral.

Cerebral hemispheres enormously developed in bulk and in the complexity of the convolutions.

Many morphological modifications have been induced by the assumption of the erect attitude.

This family includes members of the two Human species.

It is a matter for discussion whether there should be interpolated between the Families Simiidae and Hominidae another, viz. Pithecanthropidae. Till further remains of Pithecanthropidae have come to light this question must remain in abeyance. Some authors would rank Pithecanthropus erectus with the Simiidae, and others again associate this form with the Hominidae.

In concluding the account of the Order Primates, a few words may be added as to the method pursued in assigning to Man a place among the Mammals. It will have already been noticed that in the account given of the Order Primates, several morphological characters were enumerated. Should a mammal be presented for examination with a view to assigning it to its appropriate order, it would be necessary that the mammal should satisfy the conditions just referred to, before such assignation could be made in respect of the Order Primates. But the exact number of conditions is a matter upon which no final decision has been arrived at, and in practice it is found necessary for convenience in classifying animals to limit the number. An example of the procedure may facilitate this explanation. We may for instance consider the morphology of a typical Primate mammal and enumerate a dozen characters in which it presents the requisite conformation. If then we should make a corresponding list for the human body, we should find that the same conditions were satisfied in this as in the preceding case. Finally taking such a form of mammal as Galeopithecus volans (which was included among the Primates at an epoch when the single character of the possession of two incisor teeth in each jaw was regarded as the sole qualifying condition), we should see reason for regarding it as outside the limits of that Order.

The comparison may be drawn up as follows:

Characters	Homo sapiens	Generalised Primate of the Lemuroid type	Galeopithecus volans
Dentition	Dental formula $\frac{2}{2}\frac{1}{1}\frac{2}{2}\frac{3}{3}$; molars broad; angles rounded; no transverse ridges; no talon.	Dental formula $\frac{2}{2}\frac{1}{1}\frac{3}{3}\frac{3}{3}$; lower canines incisiform; molars tri-tubercular; talon present.	Dental form. $\frac{2}{3}\frac{1}{1}\frac{2}{2}\frac{3}{3}$; crowns of lower incisors are pectinated; the canine and outer incisor have double roots.
Orbital region of skull	Bounded posteriorly by a post-orbital wall.	Bounded posteriorly by a post-orbital bar.	Post-orbital processes; no bar or wall.
Clavicle	Well developed.	Well developed.	Well developed.
Forearm bones	Independent; pronation and supination occur.	Independent; pronation and supination occur.	Distally united.
Carpus and digits	Five digits; os centrale carpi not separate.	Five digits; os centrale distinct.	Five digits; os centrale carpi not separate.
Cerebrum	Large and much convoluted.	Small and feebly convoluted.	Small and almost smooth.
Uterus	Simple; not bicornuate.	Bicornuate.	Bicornuate.
Stomach	Simple; not sacculated.	Simple; not sacculated.	Simple; not sacculated.
Caecum	With Appendix.	No Appendix.	Large sacculated caecum; ? Appendix.
Mammae	Two in number; pectoral in position.	Often two pairs, one pectoral pair, one inguinal pair.	Two axillary pairs of mammae.
Testes	Scrotal.	Scrotal.	Inguinal.
Pollex	Freely opposable.	Freely opposable.	Non-opposable.
Placenta	Disc-like.	Diffuse.	Diffuse.
	[These characters qualify the animal for admission into the Order Primates.]		[These characters do not qualify the animal for admission into the Order Primates.]

Upon such evidence as is provided by the foregoing table, systematists have decided that Man is to be included within the Order Primates, while Galeopithecus is excluded from that Order and relegated to the Order Insectivora.

We have thus given a general idea of the position of the Hominidae within the Order Primates. In order to strengthen the argument for assigning to Man this position, a more detailed exposition of the anatomical characters of the Primates seems advisable. For this reason we have selected as typical examples of the Order one of the Lemurs, one of the Cercopithecidae, and one of the Simiidae. The anatomy of each of these will now (Chapter IV.) be briefly reviewed, and arranged in a manner suitable for comparison with descriptive human anatomy, which is here excluded for lack of space. To these descriptions will then be added (Chapter V.) detailed accounts of the skulls of the most nearly related family to the Hominidae, viz. the Simiidae. The dentition of the same families will also be described separately (Chapter VI.).

CHAPTER IV.

ON THE GENERAL ANATOMY OF THE PRIMATES.

IN the chapter dealing with the subdivisions of the Order Primates, the characters which have proved of taxonomic value in distinguishing the Sub-Order Lemuroidea were enumerated. The present note aims at giving a few additional facts descriptive of the anatomy of such a representative of the Sub-Order as the Lemur, taking for example Lemur mongoz, an animal about the size of a cat.

THE LEMUROIDEA.

The Skeleton. The skull (Fig. 35) is elongated, the brain-case being somewhat flattened, and the facial bones project as
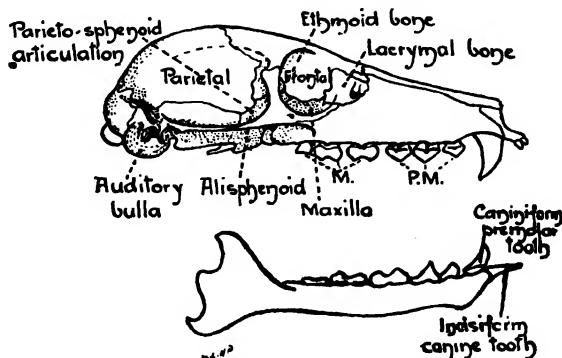
Fig. 35. Cranium, with mandible, of Lemur varius; note the auditory bulla, the articulation of parietal and alisphenoid bones, the facial extension of the lacrymal bone (cf. Fig. 12), the articulation of the frontal bone and maxilla behind the lacrymal bone, the small forward projection of the orbital plate of the ethmoid bone, the number of teeth, the small size of the upper and the great projection of the lower incisor teeth. In the mandible, the canine-like tooth is a pre-molar by position, and the canine tooth is incisiform.

a snout, at the extremity of which is the aperture of the nose. The orbit is separated incompletely from the temporal fossa by a post-orbital bar. On the inner orbital wall, the frontal and maxillary bones join along a suture which may be 5 mm. long, and thus widely separate the os planum of the ethmoid from the lacrymal bone. The nasal duct opens on the facial surface and not within the orbit. The infra-orbital canal runs along the orbital floor as a groove, and is not covered in above.

In the temporal fossa, the alisphenoid joins the parietal bone, and thus the frontal and the temporal bones are separated.

On the inferior aspect of the skull, the palate is seen to be elongated; the glenoid fossa is so shallow as hardly to merit that description: there is a well-developed post-glenoid tubercle, immediately behind which a large foramen, for the primitive jugular vein, leads to the endocranial cavity. The tympanic bone is expanded into a bulla and the external auditory meatus is very short. The sutures between the pre- and post-sphenoid, and between the latter and the basi-occipital, as well as the metopic suture, persist in adult life.

The median incisor teeth are separated by a wide interval, and are two in number in each jaw on each side of the skull. On each side (above and below) is one canine tooth. The lower canine is so modified as to resemble an incisor, and the first lower premolar resembles a canine tooth. The position of the latter with regard to the upper canine tooth shews however that it is really a premolar, for it is posterior to the upper canine, whereas the true lower canine always comes in front of the upper tooth of that name when the jaw is closed. (This view is not universally adopted however: see Forsyth Major, *Geological Magazine*, 1900.) There are three premolar and three molar teeth; the latter bear usually three cusps (though two subsidiary cusps are often developed from the cingulum), and are consequently described as of tri-tubercular type. (For fuller details, cf. Chapter VI.)

Vertebral Column. The vertebrae usually number fifty-six, viz. cervical 7, thoracic 12, lumbar 7, sacral 3, caudal 27. The spinous process of the second cervical vertebra is very large and quite overshadows the other cervical spines. The lumbar vertebrae have well-developed anapophyses which are directed

downwards and embrace the roots of the anterior zygapophyses of the succeeding vertebra. This arrangement is also found in the Cercopithecidae. As regards the curvature of the vertebral column, it is very slightly convex downwards in the cervical region. Then follows a thoraco-lumbar curve with downwardly directed concavity.

The scapula is elongated in the direction of the axis of its spine. The coracoid process is sharp and tapering and is closely applied to the head of the humerus.

The humerus has a straight shaft: the outer lip of the bicipital groove is prominent and the inner lip undeveloped. At the lower end of the bone the internal epicondyle is seen to be large and tuberous. The olecranon fossa is subdivided into two lateral halves by an osseous ridge which occurs occasionally in the higher Primates, including Man.

In the carpus, the os centrale is distinct. The pollex is diminutive, owing to the shortness of its metacarpal bone and terminal phalanx: the first phalanx equals the metacarpal in length. All the terminal phalanges are very short.

The ossa innominata are elongated antero-posteriorly, i.e. in the opposite direction to that in which their characteristic width is shewn in Man. The iliac bones are long and narrow: the pelvic brim (true pelvis) is nearly circular, thus contrasting with many lower mammalian forms and approximating to the human type. The symphysis barely extends beyond the pubic bones, and the tubera ischii are smaller and less everted than in the lower Anthropoidea.

The femur has a slender rectilinear shaft[1], a small globular head, and a short stout neck; a third trochanter may occur. At its lower end, the bone appears as though transversely compressed, when compared with the human femur. The patella is also narrow. There is a sesamoid bone in the outer head of the gastrocnemius muscle, which often remains attached to the femur. The tarsus is flat, and the heel (os calcis) is prominent; the

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[1] In the giant extinct Lemurs known as Megaladapis madagascariensis and M. insignis, there is a curious flattening of the shaft, seen in both the humerus and femur, as though pressure had been applied in the sagittal direction. The specimens in the collections at S. Kensington and Vienna present these characters.

hallux is long, and distinctly stouter than the other digits. The terminal phalanges of all the digits are very small in comparison with those situated more proximally: the terminal phalanx of the second digit is tapering and spine-like, and thus corresponds to the peculiar shape of nail which it bears.

Muscular System[1]. Panniculus system: the dorso-humeralis sheet is well developed. Below the mandible, the cutaneous musculature is divisible into a superficial (platysma) stratum, and a deeper sheet corresponding to the M. sphincter colli (cf. Ruge, quoted by Wiedersheim: *Structure of Man*, p. 106), Fig. 36.
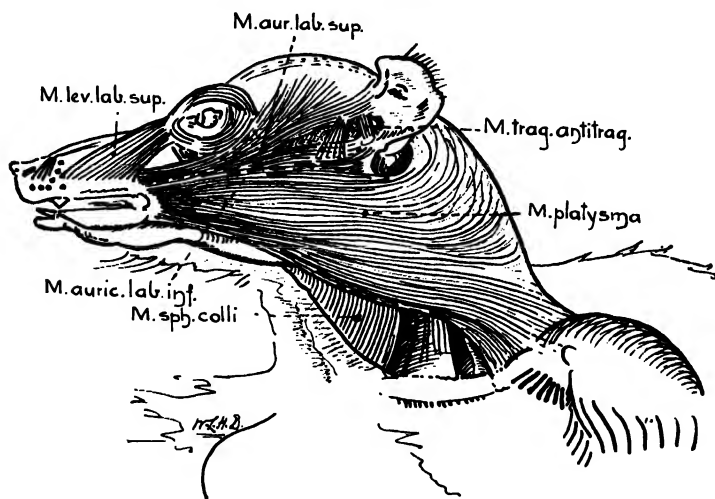
Fig. 36. Cutaneous musculature of the head of Lemur mongoz to shew some of the more definite constituents of the muscular sheet.

The M. latissimus dorsi does not blend with the M. teres major: there is a well-developed dorsi-epitrochlear muscle. In the lower limb, the M. biceps femoris arises from the tuber ischii, and is inserted not into the fibula, but into the fascia of the leg, some of its fibres running into the outer part of the fascia of the leg and being thus traceable down to the external malleolus.

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[1] Lucae's account for Lemur macaco has been mainly followed, though checked in many instances by the author's dissections. Cf. *Statik und Mechanik der Quadrupen*, 1883. (Camb. Univ. Lib. MB. 43. 14.)

The M. gluteus maximus (arising from caudal vertebrae in addition to other points of origin) is largely inserted into the posterior surface of the femur.

The adductor mass of muscles is divisible into three parts.

The M. psoas minor is present.

The M. soleus is attached to the fibula.

The M. plantaris is traceable into the plantar fascia.

The M. flexor accessorius is absent.

The M. interossei are grouped around the median digit.

Most of the muscles of the shoulder-girdle closely resemble those of Man.
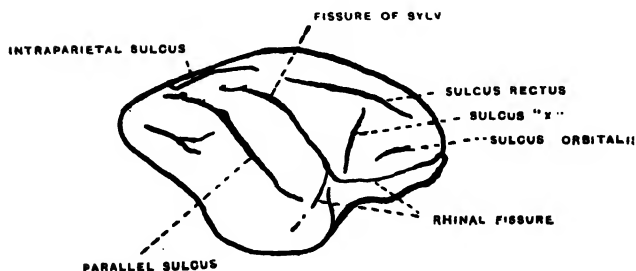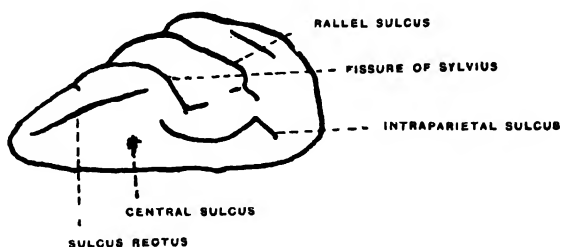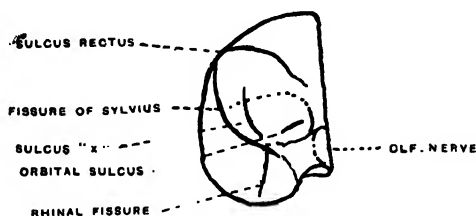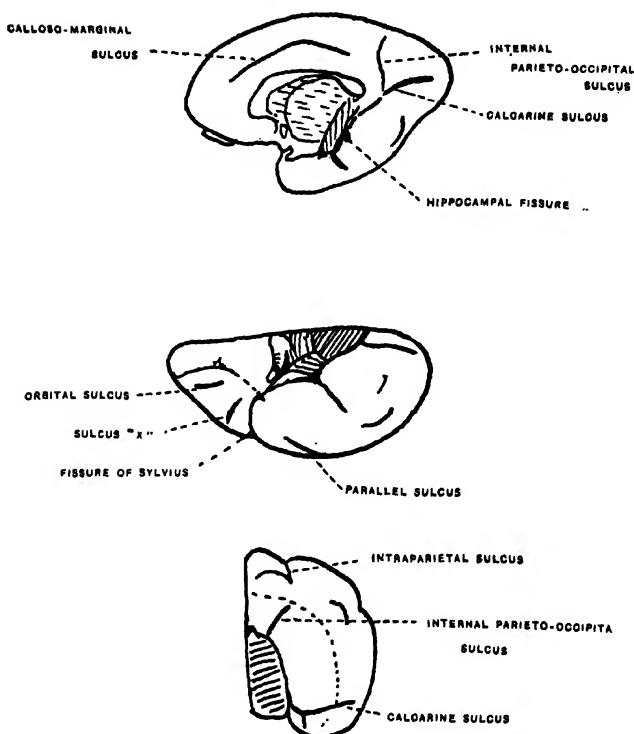
Fig. 37.   Six views of the right cerebral hemisphere of a Lemur : the first view is the frontal or anterior aspect ; then follow in turn the vertical, lateral, mesial, basal and occipital aspects : note the large size of the olfactory nerve, and the paucity of cerebral convolutions in comparison with the human cerebrum.

The M. coraco-brachialis is inserted along the greater part of the shaft of the humerus.

The M. teres major has also an extended tendinous insertion.

The M. flexor pollicis longus is not a separate muscle.

Vascular System. The Heart. The right auricle is nearly twice as large as the left. The conus arteriosus is well marked, forming a distinct bulging at the root of the pulmonary artery.

. The precaval vein, like the great arterial trunks arising from the aortic arch, is of considerable length.

The occurrence of a rete mirabile (arterial) in the limb-vessels of Nycticebus tardigradus is very remarkable.

Nervous System.   The Brain.   Fig. 37.

The rhinencephalon is distinct, the olfactory tracts being well developed, and the rhinal fissure is visible on the lateral cerebral surface, owing to the lack of development of the neo-pallium[1].

The marginal pallium is bounded by a ·hippocampal fissure, and the uncus, hippocampus major, its posterior continuation the gyrus A. Retzii, the fimbria and the fornix are all present and distinct. The neo-pallium is (comparatively) feebly convoluted, but the following sulci are distinct (a) on the lateral convexity; the Sylvian fissure ("posterior limb" of Human Anatomy), the intra-parietal, parallel, orbital, straight and central sulci: (b) on the mesial aspect; the calloso-marginal and calcarine sulci, and that component of the internal parieto-occipital sulcus of the higher Anthropoidea which is described as the para-calcarine sulcus. (Cf. Elliott Smith, *Linn. Trans.* VIII. Part 10: *The Brain in the Lemuroidea*, for full descriptions and references.)

Thoracic and Abdominal Organs[2].   The viscera occupy a lower level in comparison with the vertebral column, than is the case in the highest Primates. The Lemurs thus differ from the anthropoid apes, in which the condition more nearly resembles that found in Man.

The Lungs.   The median surfaces of the lungs shew very distinct impressed areas for neighbouring structures. The aortic groove is deeper than in Man. The trachea and oesophagus occupy distinct grooves, the trachea impressing the right lung, the oesophagus grooving the left lung.

The spleen is an elongated crescent-shaped organ tucked round the outer convex border of the left kidney. This form of spleen much more nearly resembles that of quadrupeds than that of the higher apes.

As regards the vertebral column, the left kidney is situated posteriorly to the right. Both are of small size. The duodenum

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[1] For the terminology here employed, reference should be made to Chapter xv.

[2] Cf. Dr Patten's description, *Proc. Anat. Soc.* 1900.

is of considerable length and L-shaped, consisting of a longer
vertical part and a shorter transverse part. The latter crosses the
vertebral column at the level of the 4th lumbar vertebra.

The transverse colon (Fig. 38) is looped in a very character-
istic manner (see note on characteristics of Lemuroidea in general).

Pelvic Organs. The seminal vesicles in the male are very
large: each consists of a
convoluted tube occupy-
ing about three turns of
a spiral.

The bladder resem-
bles that of the human
foetus both in position
and form. In both male
and female the rectal
pouch is very evident.

In the female, the
Fallopian tubes are short
and coiled: the uterus is
bicornuate; the clitoris
of considerable size[1].

Of the preceding
characters, the following
are of interest as throw-
ing light on certain
human conformations or
anomalies explained by
reference to the morpho-
logy of lower forms. (Cf.
Chap. IX.)

Fig. 38.   Part of the alimentary canal of a
Lemur: note the curiously contorted colon, and
the enormous appendix caeci.

1.   Extensive lacrymal bone.
2.   Post-glenoid foramen.
3.   Tri-tubercular molar teeth.
4.   Imperfect post-orbital wall.
5.   Entepicondylar foramen humeri.

[1] Dr Patten, *Proc. Anat. Soc.* 1900.

6.   Two-fold stratum of cutaneous muscles.
7.   M. dorsi-epitrochlearis.
8.   Extent of M. coraco-brachialis.
9.   Comparative paucity of cerebral convolutions.
10.   Distinctness of rhinal fissure.
11.   Form of bladder.
12.   Bicornuate character of uterus.

ANTHROPOIDEA.

As representatives of this Sub-Order there will now be considered examples of the Families Cercopithecidae and Simiidae. As a representative of the Family Cercopithecidae, a member of the Genus Cercopithecus has been selected.

The Skeleton.   The skull (Fig. 39) is distinguished by the relatively large proportions of the facial part: in males (especially
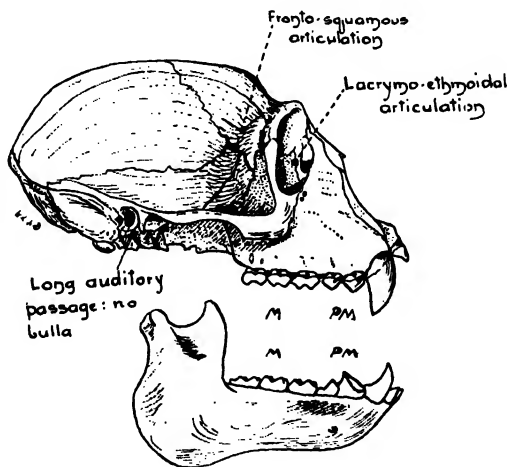
Fig. 39.   Cranium, with mandible, of a Macacus monkey (Cercopithecidae); note the absence of an auditory bulla; the substitution of fronto-squamous and fronto-maxillary for spheno-parietal and lacrymo-ethmoidal articulations: note also the number of teeth, and compare with Figs. 21 and 26.

aged animals) the temporal ridges are often prominent, and there may be prominent supra-orbital ridges.   The snout-like projection of the facial bones is pronounced in the Dog-faced monkeys, but is

much diminished in the Cercopitheci. A wall bounds the orbit posteriorly, and the nasal duct opens within the margin of that cavity. On the inner orbital wall, the lacrymal bone is separated as in the Lemuridae, from the os planum of the ethmoid, by the interposition of the frontal and maxillary bones which unite along a fronto-maxillary suture which often measures 10 mm. in length. The infra-orbital canal is not roofed over. In the temporal fossa, the alisphenoid is separated from the parietal by the interposition of the frontal and squamous portion of the temporal bone, which unite along a fronto-squamous suture. The New-World Apes commonly present the lemuroid feature of a parieto-sphenoid articulation. The malar bone in these apes may also be prolonged backwards so as to touch the parietal bone.

The palate is elongated, the glenoid fossa deeper than in the Lemurs; the post-glenoid tubercle is well developed and spiny. The tympanic bone is expanded to form a tube which protects the external auditory meatus and tympanic membrane, and there is no auditory bulla in the Old-World monkeys, though this feature characterises their New-World representatives. The anterior and inferior part of the petrous portion of the temporal bone is commonly inflated in appearance. The basi-occipito-sphenoidal suture persists for some considerable time after the completion of the dentition.

The dental formula is identical with that of Man (the New-World monkeys having an additional premolar tooth in each jaw); the molars commonly bear four distinct cusps arranged in two pairs, an anterior and a posterior. (For fuller details, v. Chapter VI.)

Vertebral Column. The cervical vertebrae are seven in number, the thoracic and lumbar together are nineteen, of which twelve or thirteen usually bear ribs, and are thus to be regarded as the true thoracic elements. Three sacral vertebrae and a very variable number (3—26) of caudal vertebrae complete the series. In the lumbar region, spine-like anapophysial processes (Fig. 40) are directed backwards from each vertebra to embrace the anterior zygapophyses of the succeeding one. The curvature of the vertebral column is much simpler than in Man, being a simple thoraco-lumbar

curv... ...ted downwards.   Anterior to this is
a c... ...pposite
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t... ...acrum, an
... ...downwards
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... ...).
... ...ry broad (Fig.
... ...in the general
...e) in comparison
...om the superior to
... its "index" is 118
...In Man, the index
is about ... ...he acromion process
is comparatively small. The scapula
in general resembles those of ani-
mals with quadrupedal gait rather
than such as have even partially
assumed the erect attitude (as the
Simiidae).

Fig. 40. Lumbar portion of the vertebral column of a Cercopithecus monkey (Cercopithecidae), to shew the anapophyses projecting laterally from the vertebral pedicles.

The outer lip of the bicipital groove in the humerus is very prominent, the inner lip being feebly developed or absent.   At the lower end of the bone, the articular surface is not so sharply differentiated into capitellum and trochlea as in the case of Man : the conformation of the capitellum, in particular, suggests that flexion and extension (the characteristic movements of this joint in animals with quadrupedal structure) have not been far en- croached upon by pronation and supination.   The angle of torsion of the humerus amounts on the average to about 100° (cf. Broca's figures : Carnivora, average angle 95° ; Europeans, 161°).   The carpus retains a distinct os centrale : the pollex is very short, owing chiefly to the diminutive size of the phalanges.

The pelvis is transversely narrow (like the " thoracic cage "), the ossa innominata being elongated antero-posteriorly, i.e. as measured from the crest of the ilium to the tuber ischii ; they thus are strongly contrasted with the corresponding bones in Man. The pubic symphysis is long, and indeed so extensive that the ischial bones come into contact, so that the symphysis is really pubo-ischiatic.   The tuber ischii is large and everted.

The femoral head ... ... mparison
with the human femur. ... ... spiralis
in some cases, but the ... ... veloped.
Inferiorly, the lack of transv ... le the
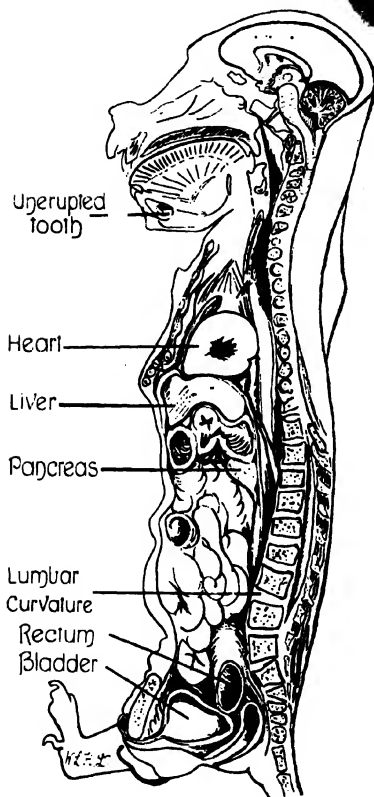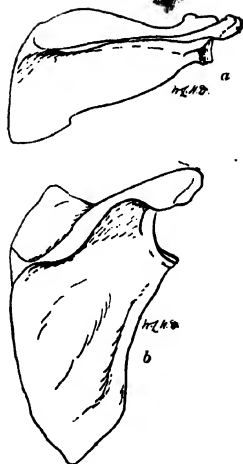
Fig. 41.   Fig. 42.

Fig. 41.   Mesial section of the (frozen) body of a Cynocephalus monkey (Cerco-
pithecidae).   Note the enormous size of the jaws, and the comparatively small
thoracic capacity and extent, and the vertebral column is much less sinuous than
in Man, but the anterior lumbar convexity is incipient and distinct.

Fig. 42.   Scapulae, (a) of a Cercopithecus monkey, (b) of Man.

curvature of the condyles is much more semicircular, when regarded
from the side, than in the case of Man.   The patella is narrow and

plays equally on each condyle. Commonly a sesamoid bone is found in the outer head of the gastrocnemius muscle.

The tarsus is flattened, and its constituents similar in number to those of the human tarsus: the hallux is very short when compared with the other digits: this is chiefly due, as in the manus, to the shortness of the phalanges.

Muscular System. The panniculus sheet is represented in the axillary region by a distinct dorso-humeral muscle. The humeral insertion of the M. latissimus dorsi is in close proximity to the tendon of the M. teres major, by which tendon it may occasionally be pierced (Kohlbrügge[1]). From the tendon of the M. latissimus dorsi, descending to the elbow, is the M. dorsi-epitrochlearis (or latissimo-condyloideus muscle) which is so constant among apes.

The M. biceps femoris possesses but a single head (the "long" head of human anatomy), which is inserted and lost in the fascia covering the muscles on the anterior aspect of the leg, and through the intervention of this fascia becomes attached to the tibia. In the American monkeys the short or femoral head of this muscle is found, as described by Windle and Parsons (*Proc. Anat. Soc.*, 1900).

The M. gluteus maximus arises from the caudal as well as the sacral vertebrae, the caudal part forming a separate caudo-femoralis muscle; the femoral insertion of the M. gluteus maximus is very small. The small separable portion of the M. gluteus minimus known as M. scansorius is not usually present.

The adductor mass of femoral muscles is much subdivided. Of the M. adductor magnus it is characteristic that the portion of the muscle supplied by the sciatic nerve is distinct from that part which receives its innervation from the obturator nerve. The insertion encroaches on the popliteal area. The M. psoas minor is usually present but is only feebly developed, as in the majority of the Primates. The M. soleus is characterized by the possession of a fibular origin only, the tibial origin not having been superadded in the Cercopithecidae. The M. plantaris tendon is inserted into the plantar fascia.

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[1] *Muskeln und Nerven der Primaten*, Amsterdam, p. 69.

The M. flexor accessorius (Quadratus plantae) is variable: in a Cercopithecus monkey it was found to possess two heads of origin (Fig. 43), though in Cynocephalus mormon but one head is found. The pedal interossei muscles are not divisible into plantar and dorsal groups as in Man, but occupy the same plane and are grouped about an axis passing through the third median metatarsal bone and digit. There is a considerable complexity and interweaving of the long flexor tendons of the digits.

With regard to muscles of the upper limb, the duplicity of the coraco-brachialis mass of muscle is to be remarked, the two components being distinguished as the coraco-brachialis longus and the coraco-brachialis brevis. The tendon of M. teres major occasionally pierces that of the M. latissimus dorsi: the deep and superficial flexors of the digits are fused to some extent at their origins, and a deep flexor tendon for the pollex springs from the tendon of the flexor profundus digitorum before the latter subdivides (Fig. 44). These flexor tendons are curiously interlaced near their insertions. There is a complete double set of extensor tendons for the digits, while to the pollex run extensors corresponding to the M. extensor ossis metacarpi and the M. extensor major of the human pollex, the M. extensor minor pollicis being absent. To the other digits the M. extensor communis supplies four superficial tendons, while the M. extensor indicis supplies deep tendons to digits II‘ and III, and the M. extensor "minimi digiti" corresponding tendons to digits IV and V.

In addition to the foregoing brief review, the constant occurrence in the Cercopithecidae of a number of muscles regarded

Fig. 43. Deep dissection of the plantar muscles of a Cercopithecus monkey (Cercopithecidae) to shew the origins of the M. flexor accessorius digitorum (M. quadratus plantae), and of the M. flexor longus hallucis. (From a dissection by Mr R. Crawford.)
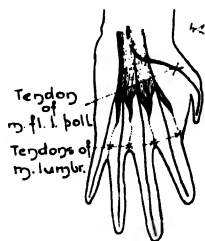
Fig. 44. Deep flexor tendons of the manus of a Cercopithecus monkey (Cercopithecidae) to shew the origins of the flexor longus pollicis, and of the lumbrical muscles. (From a dissection by Mr Graham-Smith.)

as anomalous in human anatomy is a striking feature.   Among these the following may be mentioned as being the most commonly recognised, viz.: the M. omo-cervicalis (acromiotrachelian) the M. dorsi-humeralis already mentioned, the M. occipito-scapularis (Fig. 45).   Moreover several muscular masses to which in human
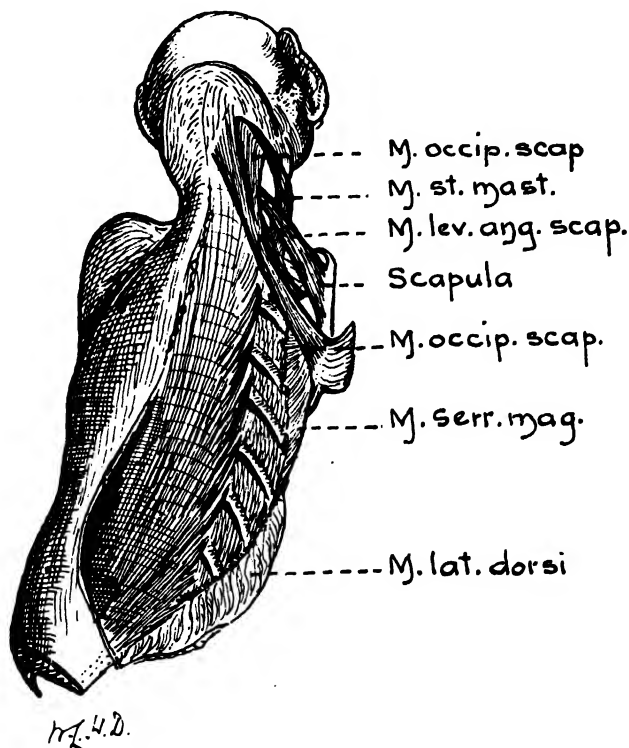
Fig. 45.   Dissection of the nuchal and cervical muscles of a young Baboon (Cynocephalus; Cercopithecidae).   The occipito-scapular muscle, a simian characteristic, is shewn.

anatomy a single name is applied, will be found to consist in the Cercopithecidae of two or more constituent elements.   Examples of such muscles are the double M. coraco-brachialis already described and the M. gracilis.

Central Nervous System: the Brain. The cerebral hemispheres are, in comparison with the cerebellum, larger than in the Lemuroidea and their surfaces are more convoluted, the principle sulci of the human brain being here recognisable, though modified much in form. This preponderance in size of the hemispheres dwarfs the quadrigeminal and geniculate bodies. The pons varolii is broad, but not so broad as to overlap the trapezium which is quite easily seen. The pyramidal tracts and olives are distinct. With regard to the first cranial nerve, it is to be noticed that the bulbous extremity is attached to the base of the brain by a long slender nerve. There is a distinct tuberculum olfactorium, and the post-rhinal fissure persists in the incisura temporalis. The relative size of the floccular lobe of the cerebellum is small in comparison with that of lower animals, the Cercopithecidae standing in this respect between these and the higher Apes with Man. The fissures and convolutions of the cerebrum (neo-pallium) may now be described in detail.

The two hemispheres are so symmetrical that the description of the right will suffice for both (Fig. 46). The Sylvian fissure, commencing inferiorly in a deep Sylvian vallecula runs upwards and appears to terminate in the parallel sulcus which is continued upwards to within 10 mm. of the upper border of the hemisphere. The Sylvian fissure runs superficially only into the parallel sulcus, for if the lips of the fissure are separated, a submerged gyrus will be observed intervening between the two fissures. The end of the parallel sulcus is received into the concavity bounded by the curved intraparietal sulcus, which itself terminates in the typical "Affenspalte," in the depths of which a submerged gyrus separates it from the entirely submerged transverse occipital sulcus. The intraparietal sulcus is joined by the external part of the internal parieto-occipital sulcus. The ramus post-centralis superior of the intraparietal is represented by a short isolated linear sulcus.

In front of the foregoing system will be observed the following additional sulci; the sulcus centralis, the lower end of which is turned slightly backwards; the sulcus rectus (inferior frontal) with a linear sulcus above it, representing the detached ascending limb; the triradiate sulcus arcuatus (inferior precentral) with a short backwardly directed limb, which resembles the corresponding

sulcus in the genus Cebus (but not that in the genus Ateles).
Above these sulci (S. rectus and S. arcuatus) are two small
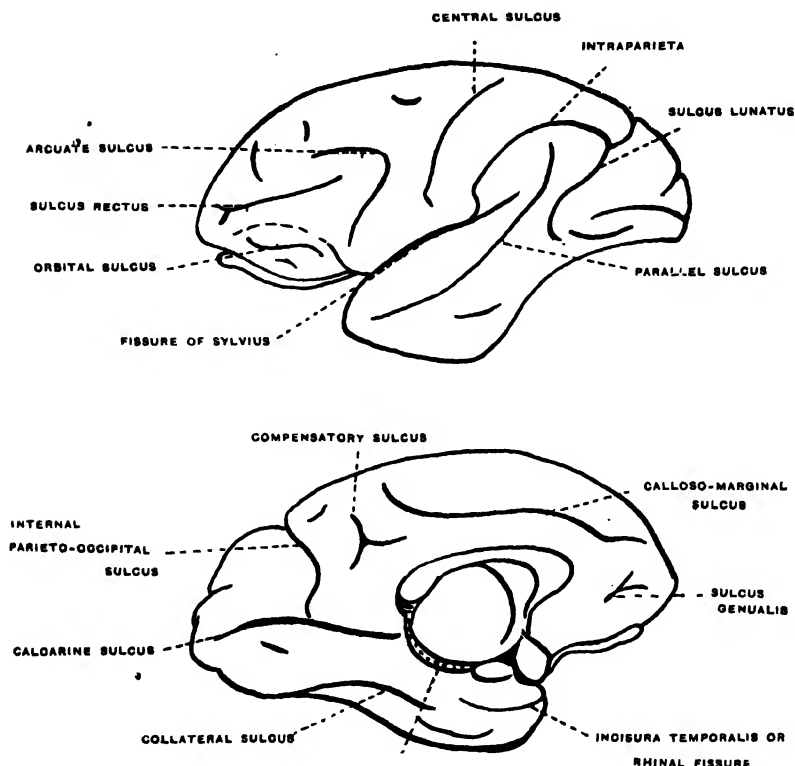
Fig. 46. The left cerebral hemisphere of a Cercopithecus monkey (Cercopithe-
cidae). The main features are similar to those of the human brain : on the mesial
aspect the small post-splenial gyrus A. Retzii is not visible, and the fascia dentata
has not been exposed.

precentral sulci, the posterior one (nearer the central) being a
mere depression, the anterior being a linear sulcus. Below the
lower end of the central sulcus is seen a small linear sulcus which
may be called the transverse[1].

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[1] Inferior transverse sulcus of Eberstaller.

On the orbital surface, the olfactory peduncle lies in a straight furrow for its posterior half. The other sulci are two, an inner triradiate, and an outer linear, the latter being directed obliquely from within forwards and outwards. No distinct fronto-orbital sulcus is seen.

The remaining sulci include an inferior temporal sulcus, in two parts, one running in the long axis of the second temporal gyrus, and the second being directed transversely to that axis. An inferior occipital sulcus running on to the temporal margin is also visible; and the only remaining sulcus is at the occipital pole and transverse and horizontal in direction.

On the mesial aspect (cf. Fig. 46) the following sulci require no special description: the genual, the calloso-marginal, the internal parieto-occipital, the "post-limbic" (which the internal parieto-occipital does not join), and the calcarine sulci, and the hippocampal fissure. The collateral is a single sulcus, and joins the calcarine very superficially only. The posterior rhinal fissure here appears as the incisura temporalis. If the crus cerebri be freely removed it is possible to see some of the structures in the descending cornu of the lateral ventricle, viz. hippocampus major and fimbria.

Alimentary System. In correspondence with the proportions of the maxillary and mandibular skeleton, the tongue is elongated and presents almost a truncated appearance anteriorly. The tonsils are small. The oesophagus has much the appearance and relations presented by the corresponding human structure, and on its way to the stomach it grooves deeply the posterior aspect of the left lobe of the liver. The latter organ is a simple sac, whence a well-developed omentum resembling that of Man extends downwards over the colon and small intestine (in one genus, viz. Semnopithecus, the stomach is extraordinarily sacculated[1]. The small intestine has the same general relations as in Man, being attached to the posterior abdominal wall by a mesentery, distinct

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[1] In one genus of the family Cercopithecidae, the alimentary canal presents some characteristic features. The monkeys thus distinguished belonged to the genus Semnopithecus, of which many species have been described. The distinctive features consist in (a) the extraordinary elongation and sacculation of the Stomach and (b) an equally remarkable modification of the form of the Liver, which, in consequence of the large size of the stomach, has been thrust across to the right side of

even in the duodenal portion of the gut, and passing (as in Man) obliquely downwards from left to right. The mesenteric glands are frequently enlarged in animals dying in this country, owing to their having succumbed to tubercular disease. The caecum is bluntly pointed and no vermiform appendix is developed. The large intestine is characterized by the possession of a well-marked mesentery for the ascending colon: the rectum is characteristically straight with well-developed mesentery. The liver possesses all the lobes distinguished in human anatomy, with the following modifications. The right and left lobes are both subdivided, the dividing fissure being much deeper in the left lobe; the caudate lobe is elongated and tapering, and like the spigelian lobe comes into intimate relationship with the structures (portal vein, hepatic

the abdominal cavity. These features are represented in the diagram (Fig. 47) of these organs in a Nasalis monkey (genus Semnopithecus).
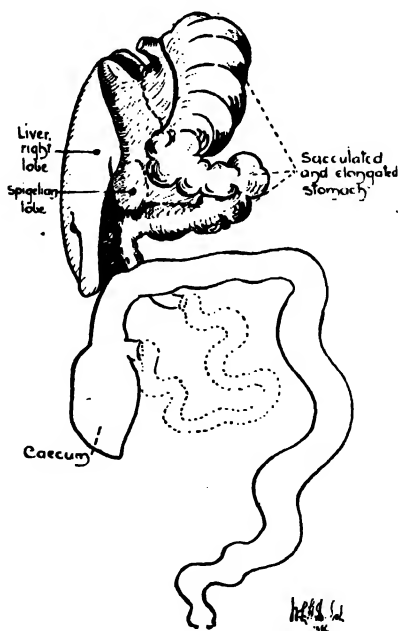
Fig. 47.   Viscera of a Nasalis monkey (Cercopithecidae) : the extraordinarily modified form of the stomach and the consequent displacement of the liver to the right are to be noticed. These features are found throughout the genus Semnopithecus, which includes many species of monkeys found in Asia.

artery and bile duct) which are situated at the right extremity of
the lesser omentum. The pancreas and spleen have similar relations
to those presented in the Hominidae, but it is to be noticed that
the spleen is covered to a very considerable extent by the liver in
consequence of the great development of the left lobe of this organ.

Respiratory System. The hyoid bone in the Cercopithe-
cidae is characterized by the enlargement and downward extension
of the basihyal, which however is not excavated as in the Cebian
Mycetes (Howling Monkey). The laryngeal apparatus closely re-
sembles that of Man, all the muscles and cartilages of the human
larynx being easily recognisable. The lungs are more subdivided
than in Man; in the left lung (Fig. 49) there are three lobes
corresponding in a general way to the three lobes normally found in
the right human lung. In the right lung (Fig. 48) the three lobes of
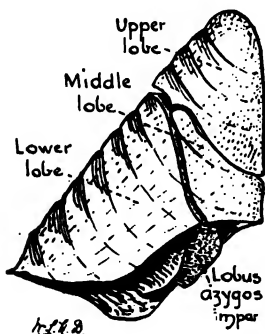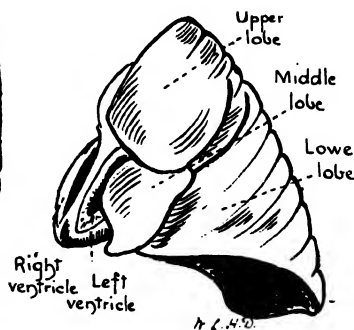
Fig. 48.   Fig. 49.

Fig. 48. Lateral aspect of the right lung of a Cercopithecus monkey (Cerco-
pithecidae) to shew the lobus azygos impar.

Fig. 49. Lateral aspect of the left lung of a Cercopithecus monkey (Cerco-
pithecidae). The heart is also shewn. The lung is divided into three lobes, thus
differing from the human lung of the left side, while resembling the right human
lung.

human anatomy will be found supplemented by a fourth lobe; this
lobe, which is small and pendulous, is known as the lobus impar:
it is situated beneath the right bronchus and sometimes it sends a
process leftwards crossing the oesophagus anteriorly and thus en-
croaching on the posterior mediastinum and left side of the
thorax.

The heart is somewhat more mesial in situation than in Man.

Thymic remains are visible on the anterior aspect of the pericardium, which is also crossed by the right phrenic nerve.

Genito-urinary System. In a young specimen of a Cephalopterus monkey (Cercopithecidae) the right kidney is situated posteriorly to the left; the right suprarenal body is elongated and nearly cylindrical, the left being pyramidal in form. The anterior renal surface is much more convex than the posterior surface. Into the renal pelvis a single pyramid bulges distinctly, though there are indications that a series of sections might reveal more than one such protrusion. The genitalia are considered in the two sexes separately.

A. The male. The testes in the foregoing example are still situated in the inguinal canal, though close to the "external ring"; it will be noted that the specimen though admittedly young, nevertheless having acquired the first permanent teeth, corresponds in age to human children of six to seven years.

The penis is protected by an elongated prepuce attached far behind the glans, a fraenum praeputii being entirely absent. The long penile urethra is supported by the cartilaginous "os" penis, and terminates posteriorly in a distinct bulb, the latter being well protected by the concrescence of the two ischial callosities in the middle line of the perinaeum. The prostate gland is large, unilobular, and firmly attached to the rectum as well as to the urethra and base of the bladder.

The membranous urethra contains a distinct spheroidal caput gallinaginis with lateral depressions.

The abdominal peritoneum is reflected almost horizontally forward from the fundus of the distended bladder.

B. The female. The genitalia of a young female Cynocephalus mormon provide material for the following notes. Externally, the clitoris is so large as to constitute a penile appendage, which however is imperforate, the urethral aperture being independent of this organ. The prepuce is long and hood-like, cleft inferiorly, and it covers a distinct and bifid glans with crura and corpora cavernosa. Like the body of this female penis however, the glans is imperforate. The former is grooved posteriorly and the urethral orifice (meatus urinarius) is still more posteriorly situated. The vagina is pro-

portionately long and straight, without a hymen: its walls are thrown into longitudinal folds, most distinct on the posterior aspect.

The pouch of Douglas is shallow, and the rectum descends almost vertically behind the uterus and vagina. No special description of the uterus, tubes, ovaries, uterine and ovarian ligaments, or bladder is called for in view of their close resemblance to the corresponding parts in the Hominidae.

The following list recapitulates characters which in the preceding account are of interest as affording explanatory evidence of certain human morphological anomalies.

1. Fronto-maxillary suture on inner orbital wall.
2. Fronto-squamous articulation at the pterion.
3. Rudimentary character of vertebral curves.
4. Additional rib-bearing vertebrae.
5. The list of muscles already given, cf. pp. 64, 65.
6. Large flocculus and floccular fossa.
7. Lack of vermiform appendix caeci.
8. Ascending meso-colon.
9. Caudate lobe of liver.
10. Lobus azygos impar.

Anthropoidea: **Simiidae.**

General Anatomy of Gorilla[1]. The skeleton. (*a*) The skull. The first point to notice in an account of the skull of the Gorilla is the great difference that exists between male and female in the adult stages, and between the immature skull and the corresponding mature stage in either sex. (Cf. Figs. 50, 51.) Museum specimens are most frequently skulls of adult or aged male individuals; female skulls of adults, and quite immature skulls of both sexes are next in frequency, and the skulls that are the most profitable for the study of the typical features of the male, viz. specimens that have not quite reached maturity, and in which the permanent dentition is just about to be completed, are the most uncommon. For this very reason such a skull will

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[1] In the *Proceedings of the Zoological Society*, 7th March 1899, will be found an admirable comparison, by Keith, of the general systematic anatomy of Chimpanzee and Gorilla.
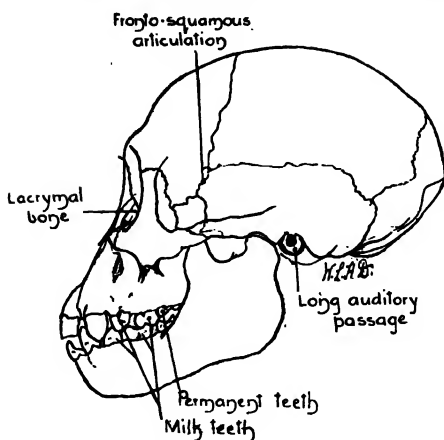
Fig. 50. Cranium, with mandible, of a young Gorilla (Simiidae) ; the first tooth of the permanent set has appeared (permanent molar tooth).   Note, in contrast to Fig. 33, the comparatively large brain-case.   There is no auditory bulla : the auditory passage is long, but not so long as in adults : there are fronto-squamous and fronto-maxillary articulations.   Osseous ridges and crests are still undeveloped.
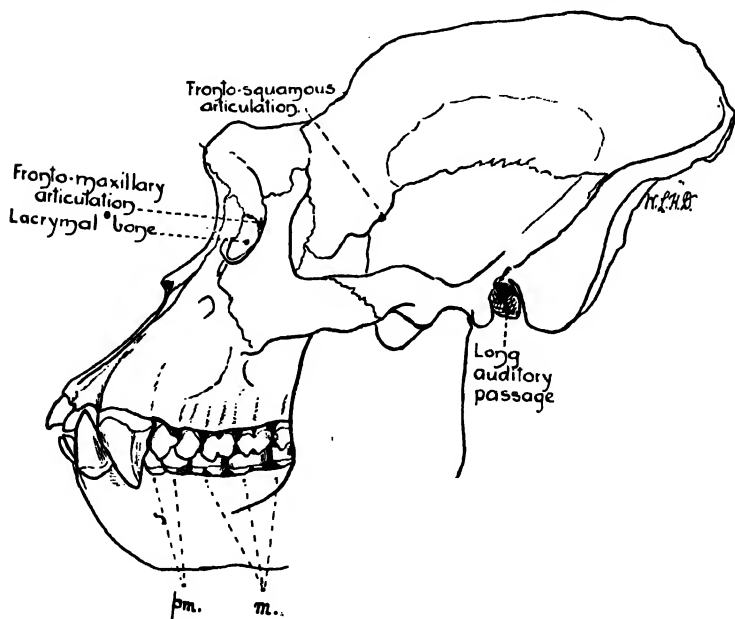
Fig. 51. Cranium, with mandible, of an adult Gorilla (Simiidae) : note the absence of an auditory bulla, the presence of great bony crests; and of fronto-squamous and fronto-maxillary articulations (the latter within the orbit in place of a lacrymo-ethmoidal junction).   The canine teeth are enormously developed in the male sex.

here be briefly described and the several features can be compared with those of specimens in the Museums. The reason that skulls of male examples fully adult or aged prove unsatisfactory is two-fold: in the first place, fusion of the various cranial bones is very precocious, and hence the relations and connections of the several bones are obscured at a comparatively early period: secondly, with maturity comes the immense development of bony ridges which indicate the great mass of the temporal and nuchal muscles. These ridges obscure the form of the brain-case.

If then we select as our example a specimen in which the permanent dentition is all but complete, we shall find that the last teeth to appear are the canines; this condition offers a contrast with that which obtains in Man, but it must be admitted that in the Gorilla the third molar is seen to break through in many instances contemporaneously with the canine, so that the difference is not absolute (*v. infra*, Chap. VI.). The skull remains to be examined systematically and the following divisions are convenient for this purpose.

A. The true cranial part, consisting of the bones (developed mostly in membrane) which protect the cerebral hemispheres.

This part of the skull is ovate, longer and narrower (more dolichocephalic) in the Gorilla than in either Chimpanzee or Orang-utan, longer and narrower in the male than in the female Gorilla. Relatively to the facial part, it is small, the reverse of the human condition thus obtaining in the Gorilla. The coronal suture is less tortuous laterally than in its middle portion, where it meets the sagittal suture. The latter is quite tortuous until the period of closure begins, when the interlocking processes are reduced in length and the suture becomes simplified and straighter. The lambdoid suture is tortuous (till closure begins) as far as the temporal bone (the " Asterion "), thence downwards it is straight. The line of suture between the parietal and squamous bones is characteristically straight in its general direction, but the squamous bone overlaps the parietal with long tongue-like processes. This margin of the parietal bone is very distinctly longer than the coronal margin, and herein is a notable difference from the human skull. Wormian bones are not uncommon in the sagittal and lambdoid sutures.

The muscular ridges have already been mentioned. In a nearly mature skull they converge rapidly from the external angular processes of the frontal bone, and each divides into upper and lower lines, the upper of which actually meet at the bregma though they diverge a little later. Herein a conspicuous difference from aged examples is offered by the adolescent Gorilla, for in the former the temporal ridges unite with one another to form a great' sagittally-directed crest which occupies the line of the sagittal suture, and secondly, each temporal ridge combines with the corresponding portion of the superior nuchal line to form a similar crest which, running coronally and along the line of the lambdoid suture, is traceable at each extremity as a ridge which crosses the base of the stunted but massive mastoid process to join the zygoma, of which it forms the posterior root.

The zygomatic arches themselves are strongly developed and though not much bowed outwardly, yet the channelling of the lateral cranial wall, especially along the line of the alisphenoid, leaves a very capacious temporal fossa. From the lambda, the contour-line of the skull descends sharply and obliquely forwards, towards the foramen magnum, the obliquity being very characteristic of the skull in all Simiidae.

B. In the facial portion of the skull the orbits first claim attention. Bounded above by a great supra-orbital ridge which is continuous from one orbital margin to the other with scarcely any interruption, and which has been described as resembling a "pent-house," the orbits have a somewhat rectangular appearance, and though the angles are rounded off, yet the general aspect is quite distinct from the oval contour which characterizes the orbit in Simia. In this respect the Chimpanzee agrees with the Gorilla. The external angular processes of the frontal bone are massive and project strongly, and this also contributes to the square-cut appearance of this part of the face (Fig. 52).

The outer margins of the orbits are indistinct and bevelled.

The lacrymal bone is reduced as in Man and though abnormal cases of a well-developed lacrymal hamulus occur, yet in general this process is even more vestigial than in the human skull. The lacrymo-ethmoidal suture is usually replaced ($65 \cdot 4 \%$ as against $34 \cdot 6 \%$ of lacrymo-ethmoidal sutures in a series of 26 males)

by a fronto-maxillary suture which may indeed be of considerable length (10 mm.): the os planum of the ethmoid is reduced considerably in vertical extent and is particularly attenuated anteriorly.
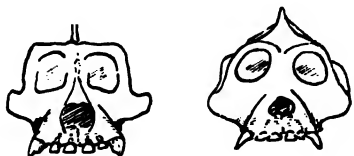
Fig. 52.   Crania of Gorilla and Simia; the former is distinguished by the massive brow-ridges which are continuous from one orbit to the other.

The number of infra-orbital foramina is variable, but the cases in which a single foramen occurs are just in excess of the other varieties.

The nasal bones are very characteristic in form, and are conjoined at an early epoch. The combined bones form a single element of the following shape. From a pointed apex on the level of the supra-orbital ridge, the margins diverge for about 10 mm. (at the level of the junction of the upper and middle thirds of the orbit); below this they approach one another again, and here a sharp crest projects from the middle line. Then the margins diverge strongly and the crest is lost at the same time.

Finally the lateral margins for the last time converge, but only slightly. The nasal bone thus extends well below the level of the orbits, and their shape distinguishes the bones in the Gorilla equally from those of the Chimpanzee and the Orang-utan. (Cf. Figs. 53, 54, 55.) The lateral margins of the apertura pyriformis nasi are clearly formed by the premaxillae which extend up even along the sides of the nasal bone. They are rounded, and the lower margins of the nasal apertures are quite indistinct. No definite nasal spine is seen, but sometimes a small tubercle occurs and in a good many cases the premaxilla throws off paired backwardly-directed processes to meet the nasal septum: these processes must not be mistaken for a true nasal spine, though suggestive of that structure. The alveoli of the great canine teeth
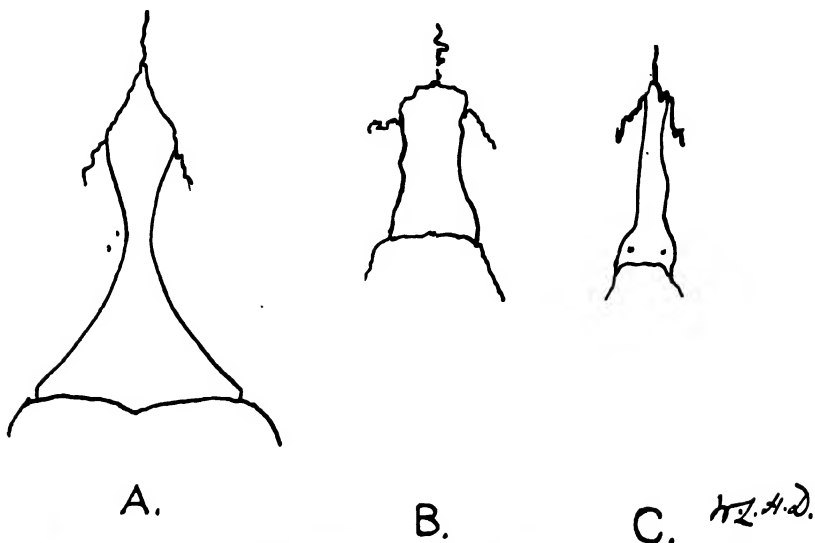
Fig. 53.   Nasal bones of Simiidae ; (A) Gorilla, (B) Chimpanzee, (C) Orang-utan.
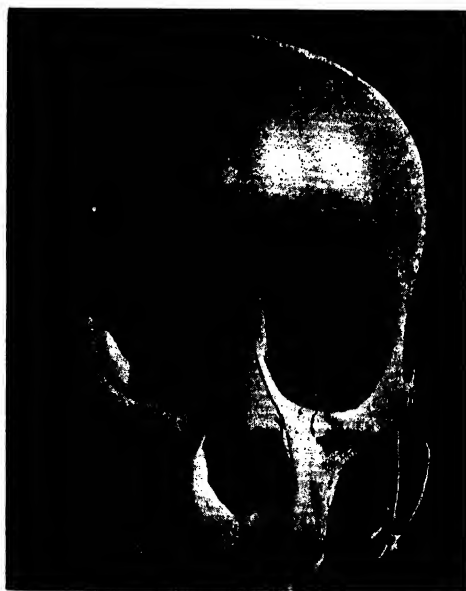
Fig. 54.

Fig. 55.

Fig. 54.   Nasal bones and intermaxillary (premaxillary) bone of a young Gorilla.
Fig. 55.   Diagram of the nasal bones and premaxilla in the preceding figure.

form projections on the facial surface on each side of the nasal aperture.

The palate has the characteristic long hypsiloid anthropoid contour, and the post-palatine spine is usually replaced by a notch. There is usually some irregularity in the arrangement of the sutures on the palatine surface, whereby the common cruciform appearance is distorted. The tuber maxillare is usually small, and the anterior palatine foramen (whence the pre-maxillo-maxillary sutures spring) is characterized by not receiving the lateral foramina (for the anterior palatine arteries).

The temporal fossa is very deep and capacious; the alisphenoid deeply channelled, and often attenuated above, in correlation with the common arrangement of a fronto-squamous articulation replacing the parieto-sphenoid junction (of the Orang-utan, of Man, and of the Cebidae and Lemuroidea): herein some of the lower human races and the Cercopithecidae agree with the Gorilla.

The infra-temporal crest is very small, and the spheno-maxillary fissure much narrowed as in the other Simiidae, which in this respect (and the concomitant approximate completion of the post-orbital wall) are more highly specialised than Man or the Lemuroidea. Sometimes the malar bone does not close in the end of the spheno-maxillary suture, but there is here a spheno-maxillary suture.

The base of the skull offers a few points worthy of special note. Anomalous processes, such as the third occipital condyle, or ossification in the suspensory ligament of the axis, and the like, are rare. The condyles are short and the foramen smaller than in Man, even in skulls absolutely larger than the human skull. The glenoid fossa is very shallow and to its inner side is a great endo-glenoid tubercle. The anterior lacerate foramen is commonly closed by osseous deposit, and the styloid process is diminutive. The tympanic bone is long and semi-cylindrical, and has no bulbous inflation.

The teeth are of the typical number ($\frac{2123}{2123}$). The canines are enormous in the males: the premolars have commonly three roots in the upper jaw; the molars bear four very clean cut ("crystalline" Dr Keith calls them) cusps in the maxilla; and in the mandible, a "talon" may bear two additional cusps. The third molar is

already shewing signs of reduction in the maxilla, despite the statements in certain works on this subject (and the Chimpanzee shews a further advance on this condition of reduction). Accessory teeth are not uncommon. First come accessory molars in the maxilla, then remnants or rudiments behind the premolars in the maxilla. An unique case in the Hamburg museum shews a double, canine tooth and sometimes a fifth incisor (of large size and só probably not a retained milk tooth) is seen in the mandible. Further details as to the dentition are provided and commented upon in Chapter VI.

The mandible is large and heavy, with no mental prominence, but a retreating chin, and deep symphysis. The genial tubercles are commonly represented by a single sharp ridge. The lower incisors project forwards and the molars have well marked cusps which may be as many as six in number. The sigmoid notch is shallow.

The foregoing notes refer particularly to the skull of a young male animal. In older males great crests are developed, sutures are obliterated, the air spaces in the maxilla (antral) increase, and the crowns of the teeth are worn smooth. In females the permanent conditions resemble more closely those just detailed, for the ridges never attain a high grade of development. Very immature specimens on the other hand differ in the lesser relative development of the facial skeleton and the greater size of the brain-case, features which approximate them more closely than adult examples of the human type. In fact from a very early period the gorilla type diverges from the human type, and the divergence henceforward becomes more marked with the lapse of time.

Skeletal System. The skeletal system (other than the skull) will be described in the following order. The vertebral column will be first considered, then the anterior limb-girdle and its limb and finally the posterior limb-girdle and limb.

In the cervical region of the vertebral column the enormous length of the vertebral spines is the most striking feature: these spinous processes are not however bifid, and thus differ from those of the human races of Europe although approached in this respect by the cervical vertebrae of some of the primitive human races.

The costal process is sometimes imperfect, so that there is no canal between it and the true transverse process. The costal process of the sixth cervical vertebra is large, while that of the seventh is very small, the same proportions obtaining as in Man.

In the thoracic region thirteen vertebrae are common, though occasionally fourteen rib-bearing vertebrae occur. Their centra appear as though laterally compressed (in comparison with those of Man): the transverse processes appear stunted but massive: the spinous processes of the lower members of this series tend to be bifurcated. The section of the thorax in the horizontal plane differs from that of Man in the relatively larger proportion borne by the antero-posterior to the transverse diameter. The thorax is thus intermediate between the human and the pithecoid type as shewn by Cercopithecidae.

The usual number of lumbar vertebrae is three, although four vertebrae are of frequent occurrence.

The lumbar centra are vertically higher and transversely narrower than those of Man. While the lateral and mammary processes are well-developed, the accessory is insignificant. Anapo-
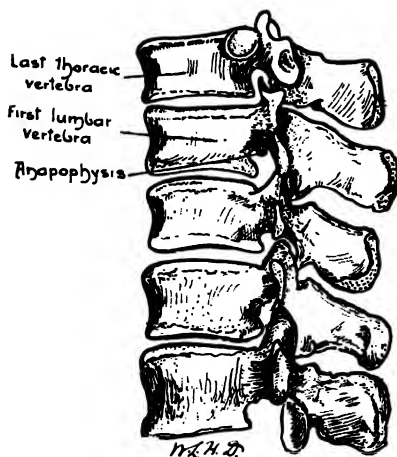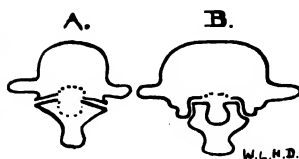
Fig. 56.   Fig. 57.

Fig. 56.   The lumbar vertebrae of an Orang-utan, shewing one vestigial apophysial process (in the first vertebra of the lumbar series). The slight anterior concavity of this part of the vertebral column is to be noted. Cf. also Fig. 40 for anapophyses.

Fig. 57.   Diagrams of the articulations between two lumbar vertebrae, (A) of Gorilla, (B) of Man, to shew the more complete interlocking in the latter example.

physes are not seen, but they sometimes occur in the Orang-utan. (Cf. Fig. 56.)

The " transverse " process of the third lumbar vertebra is small in comparison with the others and thus differs from its representative in Man. The interlocking of the vertebrae brought about by the superior articular processes of one vertebra embracing the lower processes of the vertebra above is much less effective and complete than in Man; for the former processes do not extend so far round the latter as in Man and their hold is correspondingly more feeble. This may be represented diagrammatically as in Fig. 57. The differences between the vertebral columns of Man and Gorilla are extraordinarily well-marked in this region, which is profoundly modified in correspondence with the difference between the erect attitude of Man and the crouching one of the anthropoid ape.

The sacrum of the Gorilla consists usually of six pieces, of which the laminae unite posteriorly with remarkable constancy and regularity: the variety of spina bifida which consists of a lack of union of these laminae is thus of infrequent occurrence. A well-marked sacral notch is usual, and is due to the comparative attenuation of the second sacral vertebra[1]. The coccyx is rudimentary as in Man. The sacral index[2] is stated by Turner to be 72 (Homo 112): and the curvature is small, the average depth of the sacral curve being 10·4 mm. (Paterson) as against 25·1 mm. in the (white) Hominidae.

A general review of the characters of the vertebral column shews that the Gorilla differs from Man in respect of the degree of anterior lumbar curvature. As regards the vertebral foramina, these are throughout more circular in outline than in Man; nor as regards the centra of the vertebrae does the Gorilla shew in the cervical and lumbar regions the marked excess of the transverse over the sagittal diameter so characteristic of the corresponding human vertebrae.

The pelvis is elongated antero-posteriorly (i.e. from iliac crest to tuberischii) in comparison with that of Man.

The iliac crests are more tortuous and the iliac fossae more

[1] Cf. Paterson, *The Human Sacrum*, p. 132.
[2] *v. infra.* Chap. xii.

distinct than in any other anthropoid ape, though less so than in Man, and an anterior inferior-iliac spine is sometimes found (cf. Chap. XII.).   The posterior parts of the ilia are undeveloped as compared with Man.   The ischial tuberosities are less massive than in Man.   The Os innominatum is long, and deficient in iliac breadth when compared to the corresponding human bone.   The pelvic brim is, relatively to its sagittal diameter, much narrower than that of Man.   The femur is short, stout, straight, and the shaft entirely lacks the linea aspera which is so characteristic of the human femur, being flattened sagittally.   The neck is short, and the articular surface of the head less extensive than in Man.   It makes an angle of about 124° with the shaft.   In Man this angle varies from 128°—141°.   As in Man (but unlike the condition in the Orang-utan), the ligamentum teres is found.   In the knee-joint
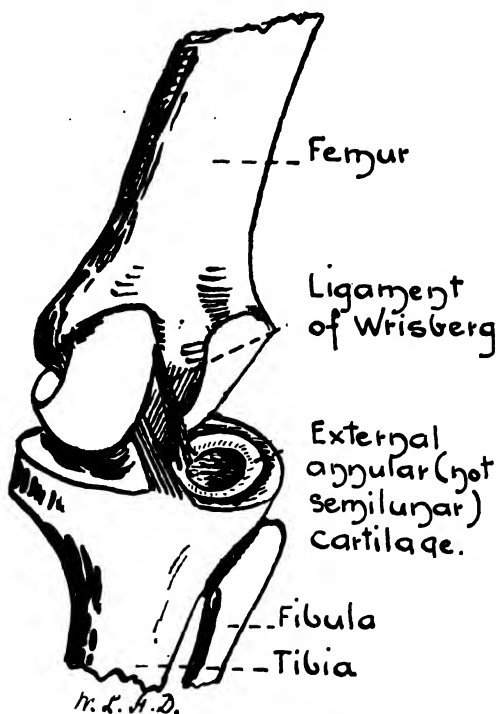
Fig. 58.   Posterior aspect of the knee-joint of a young Gorilla (right limb), shewing the annular form of external articular cartilage.

the external cartilage is annular, not semi-lunar (cf. Fig. 58). No soleal line is seen on the tibia, and the plane of articulation with the astragalus is very oblique. The fibula is very slender and its malleolus small. The calcaneum is longer and larger than in the other Simiidae, but even thus, it falls far behind that of Man in these respects. The first meta-tarso-tarsal articulation is clearly a ginglymus joint, and contrasts strongly with that of Man, the difference being evidently referable to functional adaptation.

The scapula contrasts strongly with that of Man in respect of the large extent of the supraspinous fossa. The scapula otherwise resembles the human scapula more closely than do those of the Chimpanzee, or the Orang-utan. Paradoxically, the clavicle is comparatively weak and slender, lacking as it does the bold curves and distinct muscular markings of its representative in the Orang-utan. The humerus is characterized by a similar lack of definition as regards the evidence it bears of the attachment of muscles and ligaments: thus the deltoid muscle makes but little impression on the shaft, which indicates the comparatively small size and functional activity of this muscle in the Gorilla. The average figure representative of the angle of torsion of the humeral shaft is given by Broca as 141°, European Hominidae having an average of 161°.

The olecranon fossa of the ulna is very frequently perforated (in about 80 %). The shafts of the radius and ulna are not so straight as in the corresponding human bones, and consequently the intermediate space is more extensive. In the carpus, the ossa centrale and radiale fuse as in Man (unlike their condition in the Orang, Hylobates and in the Cercopithecidae) to form the scaphoid bone of the wrist.

The sternum is flat (latisternal) and the junction of pre- and meso-sternum more commonly occurs at the level of the 3rd costal cartilage than in Man, but less usually than in Hylobates.

The following numerical data are taken from Aeby's work on the Osteology of the Gorilla[1].

Proportions of the several segments of the limbs:

Upper limb: Arm 41·1 %.   Forearm 32·7 %.   Hand 26·2 %.
Lower limb: Thigh 41·3 %.   Leg 30·5 %.   Foot 28·2 %.

[1] Cf. Gegenbaur's *Jahrbuch*, Band 4.

Muscular System. The muscular system now claims attention and will be considered in the same way as in the accounts of the Lemuroidea and the Cercopithecidae.

The muscles correspond severally with very close accuracy to those of Man, and in fact the number of distinctive human muscles, at one time thought to be thirteen, is now reduced to three (M. plantaris, peroneus tertius and serratus posticus inferior). The acromio-trachelian and latissimo-condyloideus muscles distinguish the Gorilla, not being normal in Man.

While a general agreement in the individual muscles exists, there is a definite distinction to be drawn as regards their relative development in Man and in the Anthropoid Apes. Thus while Man is characterized by the development of the musculature of the lower limb, in the Gorilla that of the upper limb has been developed. The musculature of the upper limb bears to that of the lower limb the proportion of $\frac{1}{1 \cdot 02}$ by weight in the Orang-utan (the proportion in the Gorilla will be about the same), while the proportion in Man is $\frac{1}{3}$. At the same time, when the upper limbs of the Gorilla and Man are compared, it will be seen that in the Gorilla the extensor series of muscles falls far behind that of Man in relative development ($16\,^o/_o$ instead of $22\,^o/_o$ of the total musculature[1]).

The following notes deal with individual muscles in the Gorilla.

As regards the panniculus system (cf. Fig. 59), the differentiation of the muscles of facial expression has reached to nearly the same point as in Man: the platysma muscle is extraordinarily thick and distinct.

The origin of the M. latissimus dorsi is of particular interest, in view of the relation of this muscle to movements involved by an arboreal mode of existence; the muscle arises from the tenth and succeeding vertebral spines, and in its attachment to the crista ilii is found to be much more extensive than in Man, for it arises along the whole length of this bony crest (in the Chimpanzee it may even encroach upon the region of Poupart's

[1] Langer : *Mitt. der Anthr. Ges. in Wien.*

ligament).   The tendon of insertion has similar relations with that of M. teres major to those described in the Cercopithecidae (*v. supra*).
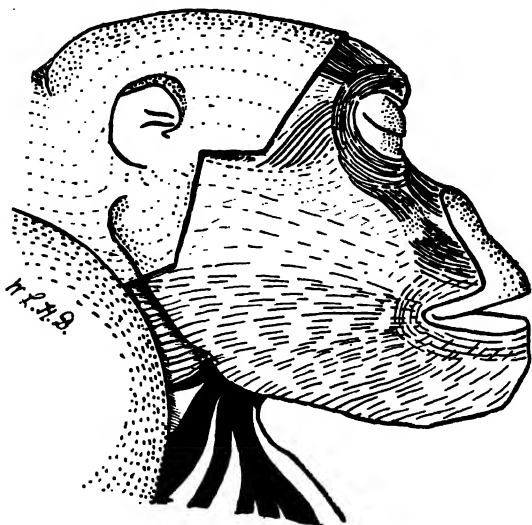
Fig. 59.   Facial musculature of an adult Gorilla.   Note the great development of the anterior fibres of the platysma.   The specimen forms part of the Holt donation to the Cambridge Collection.

The so-called Achselbogen muscle is rare.   On the other hand, the lowest fibres of the pectoral mass commonly constitute an independent muscle, the M. pectoralis abdominalis[1].   (Cf. Fig. 60.)

The M. biceps femoris commonly consists of two distinct portions, as in Chimpanzees.   (Cf. Fig. 61.)

The M. gluteus maximus arises from a fascia covering the M. gluteus medius, from the posterior part of the iliac crest, from the sacrum, greater sacro-sciatic ligament, and tuber ischii; the sacral portion is the largest, and the ischial part has been described as a separate muscle, the M. ischio-femoralis (Duvernoy).

The adductors of the thigh comprise four muscles arranged in the following manner (Deniker).

The M. adductor primus corresponds to the M. adductor longus of human anatomy, and is attached to the horizontal ramus of the

[1] Cf. Windle, "The Pectoral Group of Muscles," *Trans. Roy. Irish. Acad.* vol. xxix. part xii.

Os pubis and not to the body of that bone, as in Man.   The M. adductor secundus corresponds to the M. adductor brevis of Man, and is attached to the body of the Os pubis.   The M. adductor tertius (corresponding to the upper part of the M. adductor magnus) of Man is attached to the descending ramus of the pubis and also to the linea aspera of the femur.   It sends a slip to the M. adductor secundus.

Fig. 60.   Fig. 61.

Fig. 60.   A dissection of the pectoral and axillary regions in an adult Gorilla; the references are as follows:

1. M. pectoralis abdominalis (chondro-epitrochlearis).   2. M. pectoralis major (cut).   3. M. pectoralis minor.   4. Laryngeal sac extending into the axilla.   5. Tendon of M. latissimus dorsi, with the M. latissimo-condyleus extending down the arm.
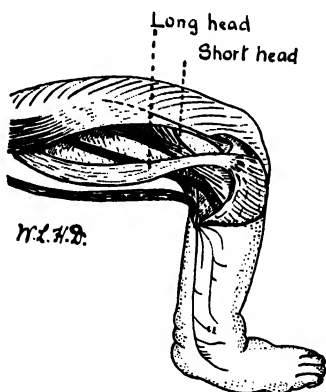
Fig. 61.   Dissection of the outer side of the thigh of an adult female Chimpanzee, shewing the two heads of the M. biceps: also the great sciatic nerve and its division.

Lastly, there is the M. ischio-condyleus, which corresponds to the condylar portion of the M. adductor magnus of Man.   The separate existence of this ischio-condylar muscle is very characteristic of Cercopithecidae and Simiidae.   It encroaches at its

insertion (as has been already said) upon the popliteal area of the femur.

The M. psoas minor is variable in its occurrence, being rather more frequently absent (60 %) than present (40 %) (Keith).

The M. soleus is of interest, inasmuch as it has been found in the Gorilla with an occasional tibial origin. Otherwise it follows the rule for Cercopithecidae, and has an exclusively fibular origin.

The M. plantaris never appears to be developed in the Gorilla as a separate muscle, although it is of common occurrence in the Chimpanzee.

The M. flexor accessorius digitorum (M. quadratus plantae) is rare, though it has been found in Gorilla (its mode of insertion in the Simiidae is also unlike that of Man, as it may in Chimpanzees form an attachment to the tendons of the M. flexor brevis digitorum).

The tendon of the M. flexor brevis to the little toe is frequently absent.

The pedal interosseous muscles are grouped about the third digit, and herein the Gorilla differs from Man and resembles the Chimpanzee, the Orang-utan, some varieties of Gibbon, and the Cercopithecidae generally: it must be admitted that many Gorillas possess the human arrangement, these muscles being then grouped about an axis formed by the second digit. In this respect the Gorilla is in a phase of evolution which is transitional and intermediate between Hominidae and the other Simiidae[1].

The deltoid muscle is characterized by the close connection between the fibres and those of the M. triceps brachii.

The M. coraco-brachialis is frequently double[2], and consists then of a long and a short portion. The muscle may be found conjoined with (a) M. latissimus dorsi, (b) M. triceps or (c) M. brachialis anticus. It has been recently suggested[3] that in respect of the M. biceps humeri the Simiidae are more highly specialised than the Hominidae; the evidence rests on the reduction observed in the lacertus fibrosus, or fascial expansion of the tendon of insertion; the Simiidae seem to have passed through a stage of evolution in which the muscle in question possessed three heads of origin.

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[1] The M. contrahentes are rare in Gorilla (Keith, *Proc. Zool. Soc.* 1899, March 7).

[2] It is however single in the adult Gorilla (Cy) dissected by the writer at Cambridge.

[3] Grönroos, *Abh. der Akad. der Wiss. zu Berlin*, 1903.

The chief characteristic of the M. teres major is the occasional great breadth of its scapular attachment.

The tendon of the M. flexor longus pollicis is sometimes absent, sometimes represented by a mere thread arising from the tendon of the deep flexor of the index, or from the anterior carpal ligament.

The M. extensor minimi digiti is represented by a tendon from the M. extensor communis digitorum.

The M. extensor indicis resembles its counterpart in Man. As for the extensors of the pollex, it is noteworthy that a M. extensor brevis pollicis, though by no means constant, is nevertheless sometimes met with. This is another instance of a transitional phase in the evolution of a series of muscles and tendons.

The diaphragm is characterized by the large proportions of the tendinous part, which leaves but a narrow zone of muscular fibre around its periphery. The pillars of the diaphragm are arranged as in Man.

Nervous System. The features of the brain of the Gorilla very nearly reproduce those of the human brain. The differences
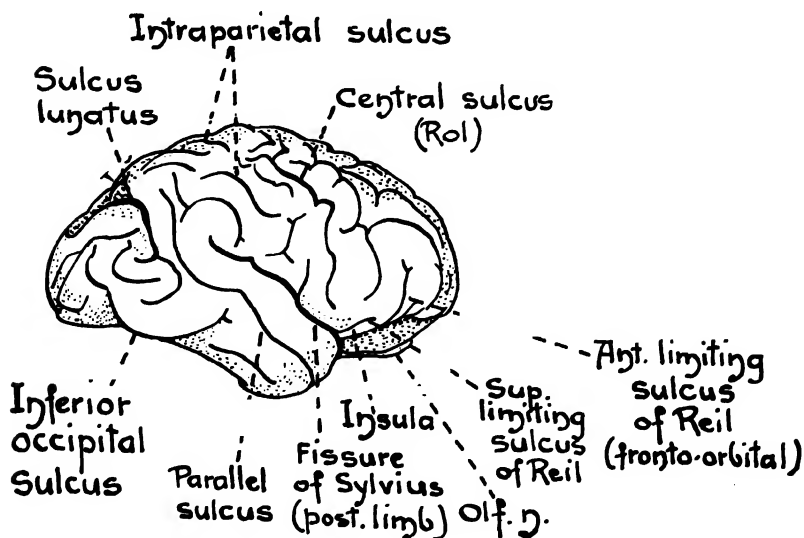
Fig. 62. Lateral aspect of the right cerebral hemisphere of a young Gorilla (Simiidae). The olfactory nerves are attenuated in point of size: the cerebral surface is much more convoluted than in the preceding examples and recalls the appearance of the human cerebrum. Cf. with Figs. 20, 23, 24, 25, and p. 38.

are chiefly those of absolute size, and the Gorilla-brain has not attained to such a high degree of development, as regards the amount and the complexity of convolutions of the cortex, as the brain of Man.   When compared with the other large anthropoid apes, the Gorilla is seen to stand in a position nearer to Man than these.   There is however in the Gorilla a marked sexual difference in the size of the brain.   In general form (cf. Fig. 62) the cerebrum is ovoid, and strongly rostrated anteriorly, the frontal lobes being deeply excavated inferiorly by the upward projection of the orbital plates of the frontal bone. The frontal lobes are thus less full and rounded, both absolutely and proportionately, than those of Man.   The occipital end of the hemisphere does not overlap the cerebellum to the same extent as in Man, and the cerebrum is smaller in proportion to the cerebellum than in the human brain.   The following notes are based upon Professor Elliott Smith's description of the brain of a Gorilla in the Museum of the Royal College of Surgeons.   At the base of the brain the posterior rhinal fissure is retained with diagrammatic clearness, and thus demarcates the neo-pallium from the pyriform lobe.   There is a deep vallecula Sylvii, which leads into the stem of the Sylvian fissure.   The latter is formed by the meeting of temporal and orbital opercula as in the human brain. As these opercula extend laterally they diverge, and expose a small triangular depressed area of insula.   The orbital operculum is limited by a distinct fronto-orbital sulcus, which is really the anterior limiting sulcus of the insula.   A dorsal opercular fold demarcates the lateral (superior) margin of the insula, and makes so complete a superior limiting fissure, that it appears to join the anterior limiting (fronto-orbital) sulcus, though closer examination reveals a strip of cortex dividing the two sulci.   In most brains of Gorilla this strip is wide and quite easily seen.   The mesial end of the fronto-orbital sulcus does not usually join the stem of the Sylvian fissure.   The orbital surface of the frontal lobe is marked by a tri-radiate orbital sulcus to which smaller sulci may be accessory.   The central sulcus presents a well-marked " genu."   On the lateral surface of the frontal lobe, well-marked representatives of the sulci rectus and arcuatus are seen, and are evidently representative of the inferior frontal and inferior pre-central sulci

of human anatomy. The superior pre-central and superior frontal sulci are arranged almost diagrammatically. A small sulcus frontalis medius and a representative of the sulcus fronto-marginalis (of Wernicke) may occur. The inferior transverse sulcus is commonly absent, but Eberstaller's sulcus diagonalis occurs.

The parallel sulcus is hooked round the extremity of the Sylvian fissure, much as it is in the Cynocephalous apes. The intra-parietal sulcus is clearly recognisable: the ramus ' post-centralis superior is commonly independent of the last-named sulcus which dips posteriorly under the occipital operculum. The arcus occipitalis is very large, and wholly exposed, the mesial end of the occipital operculum having been pushed completely outward and backwards. A Y-shaped lateral occipital sulcus cuts into the occipital pole of the hemisphere. The occipital operculum is bounded by an almost semicircular Affenspalte.

The calcarine sulcus (cf. Fig. 63) consists of an anterior deep (true calcarine) portion, and a shallower retro-calcarine element, the latter being strongly inflected at its posterior end. A dorsal post-calcarine sulcus runs parallel to this last-mentioned portion.

The sulcus parieto-occipitalis of the mesial aspect is constant in occurrence, but very variable in extent and connections. The collateral sulcus may join the posterior element of the occipito-temporal sulcus, and operculation occurs in this region as it does in the genera Cynocephalus and Macacus. The calloso-marginal sulcus is very complete; and Broca's "compensatory" sulcus also occurs.

The cerebellum closely resembles that of Man. The floccular lobe however is larger than in human brains, and consists of two lobules each attached by its own stalk. Of these one, the mesial, is much the larger and is composed of three separate groups of folia whose separate peduncles unite in a common stalk. The lateral lobule is smaller and almost hidden by the former. It represents the flocculi secundarii of Man, which may correspond to the paraflocculus of lower mammals. The olivary body is in contact with the lower margin of the pons. No trapezoid body is exposed. The mesial geniculate body appears in some cases to be much more prominent than in Man (a prominence possibly associated with the larger size of the auditory nerve).

Though it is not possible to enter here upon the physiology of the brain of Gorilla, yet it must be mentioned that in experiments
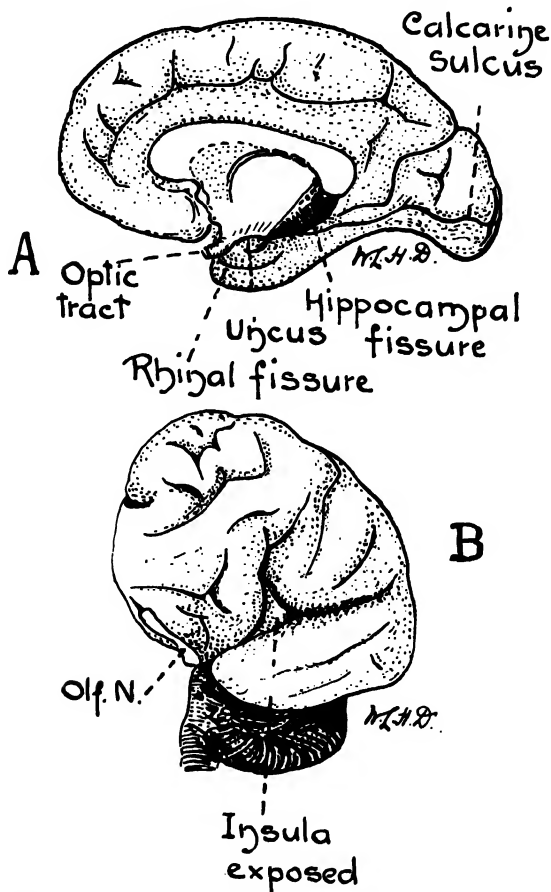
Fig. 63.   Mesial (A) and frontal (B) aspects of the right cerebral hemisphere of a Gorilla (from a specimen in the Anatomy School at Munich).   Note the very great similarity in appearance, as regards the mesial aspect, to the human cerebral hemisphere.   The rhinal fissure (incisura temporalis) is conspicuous.   In (B) note the uncovered state of the insula and the lack of definite anterior limbs of the fissure of Sylvius.

undertaken with a view to the investigation of cerebral localization, the brain of this anthropoid, when examined by Sherrington and Grünbaum, yielded the startling evidence that the motor areas of the cortex are exclusively situated posteriorly to the central fissure.

This result contradicts those obtained by earlier observers who have examined the brains of other anthropoid apes, and particularly necessitates a revision of the statements of Horsley and Beevor with regard to cortical cerebral localisation in the Orang-utan. At the same time, it must not be forgotten that considerable individual, not to say specific, variation may exist, and a fuller knowledge of the facts may lead to an explanation on these grounds of this discrepancy in observations.

The peripheral nervous system offers a certain number of differences from that of Man:

The following list given by Eisler[1] shews some of the chief divergences from the normal human arrangement of nerves presented by the Gorilla.

The facial nerve is more complicated in the Gorilla than in the Chimpanzee, but less so than in the Orang-utan and in Man: its communications with the external carotid plexus are richer than in Man.

The glosso-pharyngeal nerve communicates freely with the tenth, twelfth, and sympathetic nerves. It may consequently appear deficient in pharyngeal branches.

The ramus internus of the superior laryngeal branch of the Vagus may perforate the thyroid cartilage.

The ramus descendens hypoglossi contributes to the innervation of the sternomastoid muscle. The ansa hypoglossi receives branches from the first two cervical nerves.

The great auricular and the superficial cervical nerves come from the second cervical only, the supra-clavicular from the second, third and fourth cervical nerves.

The phrenic nerve contains sympathetic fibres.

The supra-scapular nerve comes from C. IV. and C. V. (C. V. and C. VI. in the Hominidae).

The nerve to the M. subclavius is not a distinct entity. The internal cutaneous nerve is derived principally from the first thoracic and intercosto-humeral branch of the second thoracic nerves.

The musculo-cutaneous nerve receives no contribution from C. VII.; it supplies the M. coraco-brachialis, but does not perforate it.

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[1] "Muskeln und periphere Nerven des Gorilla." Halle-a-S. Exhaustive descriptions have also been published by Bolk, Sperino, and Kohlbrügge.

Fine vascular branches are supplied to the brachial artery by the ulnar, as well as by the median nerve; the deep volar branch of the ulnar nerve springs from a communication between the ulnar and median nerves, and passes beneath the ligamentum carpi volare proprium to enter the hand.

The median nerve passes beneath the M. pronator teres.

The upper cutaneous branch of the radial nerve is absent, and its place is taken by a twig from the circumflex nerve; the radial nerve does not perforate the M. supinator brevis. The ilio-hypogastric and ilio-inguinal nerves arise from the thirteenth thoracic nerve, which is accordingly considered by Eisler as representative of the first lumbar nerve of Man.

The anterior crural nerve receives most of its muscular fibres from L. IV.

No contributions to the sciatic portion of the sacral plexus come from nerves posterior to the second sacral.

The pudendal plexus is formed by the second and third sacral nerves, the coccygeal plexus by S. IV. and S. V.

The long pudendal and inferior haemorrhoidal nerves are completely independent of each other.

The anterior tibial nerve supplies (in correlation with the shifting fibula-wards of the dorsal interosseous muscles) the opposed surfaces of the second and third toes.

In the sympathetic chain three cervical ganglia are found, in addition to the ganglion stellatum; the second and third ganglia are placed more anteriorly than in Man.

The sympathetic chain, the splanchnic nerves, and the vena hemiazygos pass together through the diaphragm.

A ganglion mesoraicum medium, not found in Man, lies between the aortic and coeliac plexuses.

In many instances a single sympathetic ganglion is connected with two or more spinal nerves, and *vice versâ* a single spinal nerve may send contributory fibres to two sympathetic ganglia.

The general distribution of cutaneous nerves to the lower limb of a Chimpanzee is shewn in the accompanying illustrations. (Figs. 64, 65, 66.)

External Cutaneous Nerve

Branches of the External Cutaneous and Anterior Crural Nerves

Muscular

Internal Saphenous Nerve

Musculo-cutaneous Nerve

Internal Saphenous Nerve

Fig. 64.

Sacral Nerves

Branches

of

External

Cutaneous

Nerve

Recurrent Gluteal Nerve (lesser sciatic)

Branch from Anterior Crural Nerve

Internal Saphenous Nerve

External Saphenous Nerve

Branches of Internal and External Plantar Nerves

Fig. 65.

Fig. 66.

Figs. 64, 65, 66. Dissection of the lower limb of a Chimpanzee to shew the distribution of the cutaneous nerves. Note the lack of cutaneous fibres from the obturator nerve, and the absence of filaments from the anterior tibial nerve to the cleft between the hallux and first toe.

Alimentary System. The tongue is elongated, is not pointed, but has a nearly rectilinear anterior margin. The relation of its breadth to its length is stated by Ehlers to be as 1 : 3·6. Fungiform, filiform and caliciform papillae, the latter commonly numbering five, are found on its upper surface. Posteriorly to these are numerous conical papillae. A lingual fraenum is found, as well as two folds which guard the orifices of the Whartonian ducts, and which are occasionally well developed in Man. There is also another fold corresponding to the plica fimbriata of Gegenbaur, and which is said to be developed in the larger Anthropoid Apes and in Man but to be lacking in the Cercopithecidae and Cebidae. Palatal folds or ridges are also seen. The salivary glands (parotid and sub-maxillary) have approximately the same relations as in Man.

The stomach is a simple sac, having similar relations on the whole to those of the human stomach, with the exception that as regards the transverse colon the human stomach is higher, that of
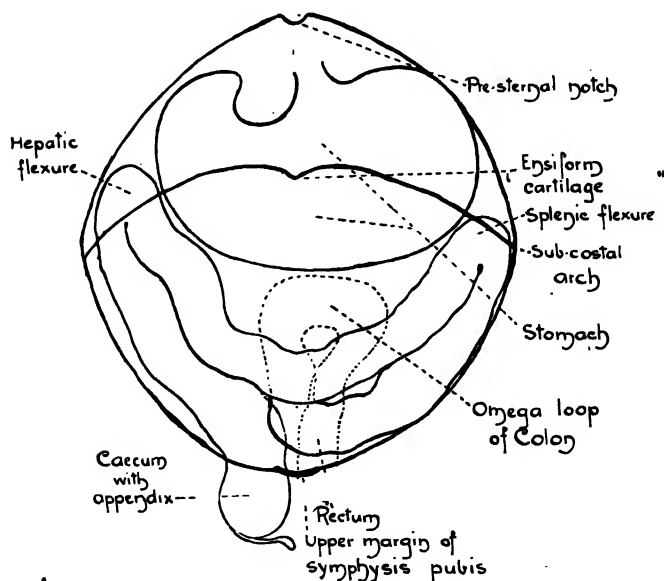
Fig. 67. Diagram (to scale) of the relations of the stomach and large intestine in an adult male Gorilla ("Cy").

the Gorilla being often lower and thus rather behind than above the transverse colon. In the adult Gorilla the human arrangement may however obtain. (Cf. Fig. 67.)

The small intestine is quite distinct in appearance from the large: the relative lengths of these two portions of the gut vary in the following way; in a foetus of 5 months the length of the small intestine was to that of the large intestine as 3 to 1; in a young Gorilla the proportion 4·8 to 1 has been found, and in an adult Gorilla the proportion of 2·1 to 1 obtained. There would thus appear to be irregularity in the rate of growth of each portion of the gut, and the irregularity is of a reciprocal kind. The general characters of the intestine do not differ materially from those of the human intestine. Deniker suggests that in the Gorilla the vermiform appendix caeci increases in relative size with the age of the animal, whereas it decreases with age in Man. (For the position of the caecum cf. Figs. 67 and 68.)
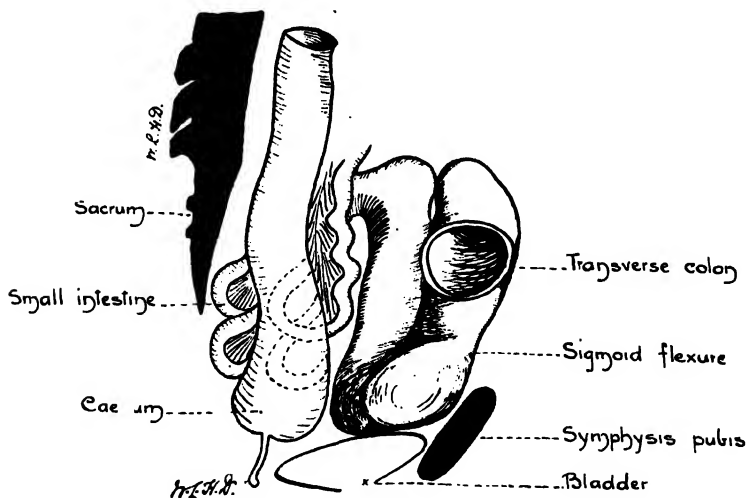
Fig. 68.   Abdominal and pelvic viscera of an adult male Gorilla, seen from the right side. Note the extent to which the caecum and appendix have descended into the pelvic cavity. (Holt donation ; Mus. Anat. Cant.)

The pancreas does not differ apparently from that of Man : the characters of the spleen however are distinctive, the most striking being the extreme attenuation of this organ in its lower parts, so that its extremity is tapering and caudiform.

The liver of the Gorilla (cf. Fig. 69; the inferior aspect of the liver of a young Gorilla is represented) differs from those of the other large anthropoids and of Man in the important character of the tendency to subdivision of right and left lobes, a character
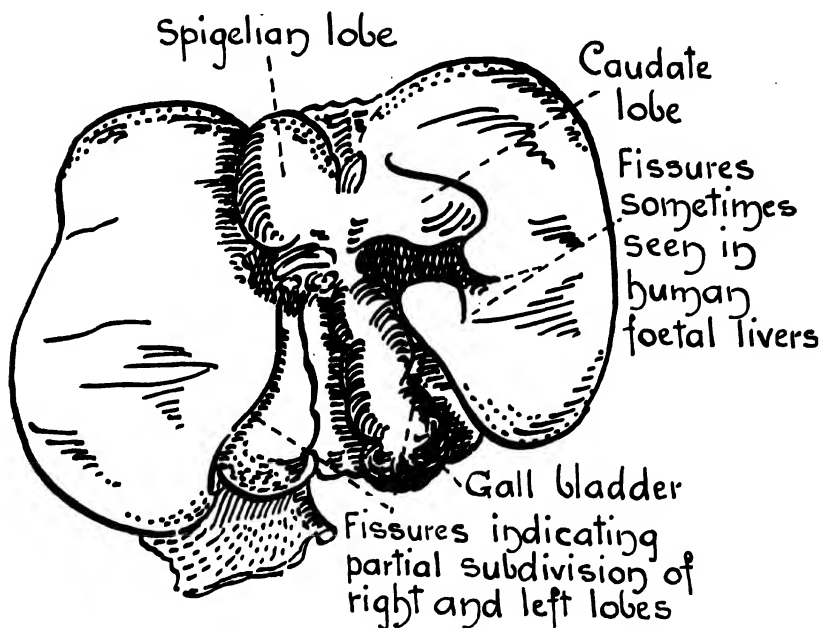
Fig. 69.

which assigns a comparatively lowly place to the Gorilla in a comparison of the higher Primates based on the anatomy of the liver.

The general relations of the peritoneum are the same as those of Man.

Vascular System. The heart closely resembles the human organ: in respect of length it bears to the stature a slightly higher ratio than is the case in Man. The differences between the arterial system of the Gorilla and Man are few and insignificant. The arrangement of the great arteries springing from the arch of the aorta is identical with that of Man in 89 % of examples. The lingual artery may arise from the facial, as is

sometimes the case in Man.   In the hand, the superficial palmar arch is frequently incomplete through the failure of the superficial branch of the ulnar artery to supply more than two and a half digits, the remaining two and a half being supplied by an enlarged A. superficialis volae.   In the lower limb, a striking difference from the human arrangement of arteries is provided by the saphenous or internal tibial artery, which in many anthropoids replaces the anterior tibial artery of Man, and corresponds exactly to the radial artery in the upper limb.

In other respects the general arrangement of vessels is similar to that which obtains in Man.   The following notes taken from Eisler's work[1] shew that individual examples may present conformations met with in Man as anomalies only.   Eisler states that the heart of Gorilla is placed further to the left than in Man.

The posterior auricular and the occipital arteries arise by a common stem.

The ulnar artery passes deeply to the anterior annular ligament (not over it as in Man) and proceeds beneath the piso-unciform ligament with the ulnar nerve.

Both the superior intercostal arteries and an arteria trachealis azygos (thyroidea ima) spring from the arch of the aorta.

The middle sacral artery gives off two lumbo-sacral arteries and then divides into two lateral sacral vessels.

The dorsalis pedis artery is largely, sometimes entirely, replaced by the long saphenous artery already described.

The following statements refer to veins.

Among the superficial veins of the forearm and arm only the cephalic vein occurs constantly as a distinct trunk.

The superior intercostal vein opens into the vena cava superior passing anteriorly to the aorta.   No communication is made with the subclavian vein.

The eighth intercostal vein of the left side passes anteriorly to the aorta and into the vena azygos.

A deep saphenous vein supplements the long saphenous vein in the thigh and accompanies the arteria saphena magna (long saphenous artery).

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[1] Eisler (*op. cit.* p. 121).

Respiratory System. The hyoid bone of the young Gorilla becomes ossified at a relatively earlier epoch than that of Man, possibly in relation to the development of the laryngeal pouches in the former. The laryngeal pouches (cf. Fig. 60) are enormously dilated laryngeal ventricles, which pass out outwards through the thyro-hyoid membrane of each side and extend downwards as far as the axillae, passing beneath the clavicle and the pectoral muscles.

The bronchi are less divergent than in Man : their ultimate division is quite similar to the human arrangement. The division of the lungs resembles that obtaining in the Hominidae, and the lobus azygos impar is occasionally though not always found.

The thyroid gland is situated rather higher up on the trachea than in Man : the isthmus may be distinct, though this feature varies. The thymus is voluminous in the foetus at 5 months : its disappearance would appear to be more rapid than in Man.

Genito-urinary System. The Genito-urinary system offers no important differences from that of Man.

The kidneys may present but a single pyramid as in Hylobates, but this is a variable character in Gorilla. The genitalia of the female differ in arrangement from the human type, inasmuch as the vulva is directed posteriorly. The vagina, uterus, Fallopian tubes, and ovaries resemble the human organs. The existence of a hymen is denied by various observers : this membrane would thus appear to characterise the Hominidae alone among the Primates.

In the male, the glans penis is smaller relatively and absolutely than that of Man, but is nevertheless more distinct and relatively larger than in other Simiidae. There is an os penis, as in the lower Primates, and other Eutherian mammals. The Hominidae amongst Primates alone would seem to be characterised by its absence.

Integumentary System. Cutaneous grooves on the palms of the hand and the soles of the feet are divisible into three series, viz.

'(a) a transverse group, expressive of the action of flexor muscles.

(*b*) a longitudinal group, developed in correlation with adductor action between the thenar and antithenar eminences.

(*c*)   an oblique group, expressive of the action of opposition of the pollex (or hallux) to the other digits.

This survey of the main characters of the Simiidae shews their close similarity to the Hominidae : at the same time differences as well as resemblances are indicated, differences chiefly noticeable in two connections, viz.: with the adaptation of Man to the erect attitude, and secondly, with the concomitant development of brain-mass and function.   These two principles are closely allied, and the mode of adaptation of the Primate type to an erect position, and the characters attendant on the greater cerebral development will be considered in some of the ensuing chapters.

The following list comprises some of the principal characters of Gorilla which aid in the elucidation of various human morphological anomalies.

1.   Fronto-maxillary suture in the orbit.
2.   Fronto-squamous suture at the pterion.
3.   Non-bifid vertebral (cervical) spinous processes.
4.   Rudimentary vertebral curvatures.
5.   Additional rib-bearing vertebrae.
6.   Perforation of the olecranon fossa.
7.   Separate ischio-condylar muscle.
8.   Variable origin of M. soleus.
9.   Disposition of M. interossei of foot.
10.   Double M. coraco-brachialis.
11.   Lack of operculation of central cerebral lobe.
12.   Tendency to subdivision of lobes of liver.
13.   The saphenous artery.
14.   Dilated laryngeal saccules.

CHAPTER V.

THE CRANIA OF THE SIMIIDAE (PRIMATES).

HAVING completed a general account of the anatomy of selected types of the Primates, we turn to the cranial characters of the Simiidae in particular; and inasmuch as the skull of Gorilla has already been described, this form will demand less attention here than the remaining members of the family, viz. the Gibbons, Orang-utans and Chimpanzees. To the first of these, the Gibbons, we may now turn, taking as our examples skulls of animals of the Bornean variety known as Müller's Gibbon (Hylobates mülleri), and proceed to consider the points laid down in the accompanying list.

I. Cranial portion:
> General contour.
> Sutures.
> Ridges.

II. Facial portion:
> Orbit: General contour and margins.
> > Lacrymo-ethmoidal suture.
> > Lacrymal hamulus.
> > Infra-orbital suture.
>
> Nasal aperture:
> > General contour.
> > Lower margins.
> > Nasal spine.
> > Nasal bones.

contour.
atine spine.
maxillare.
he sutures.
Fossa:
res at pterion.
oth of fossa.
t-orbital wall.
he skull: Glenoid fossa.
ndoglenoid tubercle.
Margin of foramen magnum.
Styloid process.
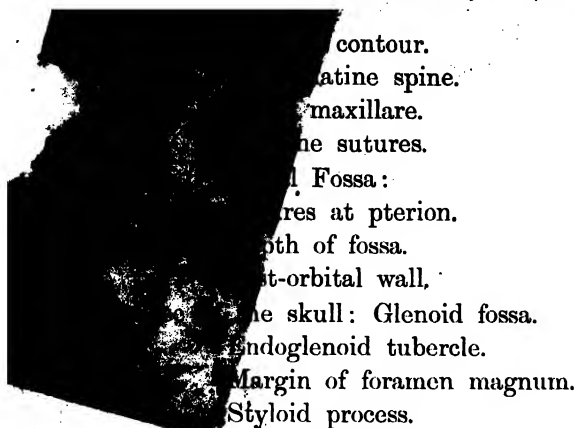
    V.   Dentition: Number of teeth.
                     Characters of teeth.

   VI.   Mandible.

CRANIAL CHARACTERS OF HYLOBATES MÜLLERI.

As is to be expected from the smaller size of the animal, the skull (Fig. 70) is much less bulky than that of the Gorilla (or indeed of the other Simiidae): in length the brain-case (cranium)
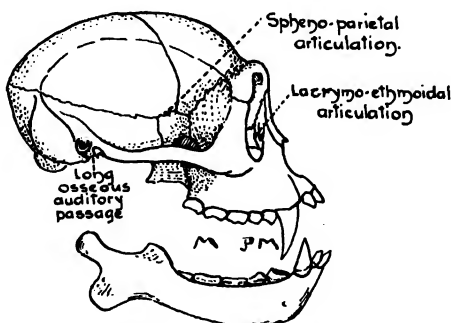
Fig. 70. Cranium (with mandible) of Hylobates mülleri: note the absence of an auditory bulla; there are spheno-parietal and lacrymo-ethmoidal articulations. Note also the number of the teeth. (Hose donation II; Mus. Anat. Cant.)

will be found to measure about 75 mm., whereas in the larger animals of this family twice that figure would represent the corresponding dimension.

In size and in general appearance the skull resembles those of the higher Cercopithecidae rather than those of the Simiidae. It

is to be noticed that the brain-case is   ge in
comparison with the facial skeleton, that   that
the surface of the cranium is devoid of p   ugh
the outline of the area occupied by the te   n
by an upraised linear ridge. The sutur   l.
mention.   The orbital cavities are remarkabl
latter feature is associated with the small size
accordance with a general law as to the proport
between the animal's absolute bulk and the size
This feature detracts from the appearance of post-or
compression of the skull, which would otherwise be ma

Turning now to other facial characters, it will be
the orbital margins are distinct or trenchant, that the
hamulus is vestigial, that the os planum of the ethmoid
infrequently divided into anterior and posterior portions, and that
the spheno-maxillary fissure is widely open.   The infra-orbital
suture does not persist on the facial aspect.   The nasal aperture
has an ovoid form or contour, with margins which are obliterated
inferiorly.   No nasal spine is seen: the nasal bones are early
conjoined by synostosis, and the compound bone has a somewhat
quadrate contour and is flat, not suggesting the prominence of
the soft parts of the nose.   The palate is hypsiloid (U-shaped) in
contour, with a diminutive posterior spine: the tuber maxillare
is also diminutive.   In the region of the temporal fossa the
rudimentary character of the alisphenoid (as compared with its
condition in Man) is at once seen: this bone joins the parietal
at the pterion: and the infra-temporal crest is insignificant.

At the base of the skull the shallowness of the glenoid fossa
arrests attention, and it is noticed that no endoglenoid tubercle
is developed as in the Gorilla, though a post-glenoid process is
distinct.   The styloid and vaginal processes are not seen.

The dentition provides the normal formula for Catarrhine
Primates.   The canines greatly exceed the neighbouring teeth in
size: the molars are tetracuspid and the talon in the lower molars
is not conspicuous.

The mandible is characterised by the shortness of the ascending
ramus, by the projection of the angle and by the absence of genial
tubercles.

CRANIAL CHARACTERS OF SIMIA SATYRUS.

Next in order will be taken the Orang-utan (Simia satyrus). The researches of Selenka of Munich led him to distinguish some seventeen different varieties or local races of Orang-utans: as the differences by which these races are distinguished affect only secondarily the skull, it will not be necessary to specify the particular variety described and indeed in the absence of the soft parts this would be a difficult if not an impossible problem.

Taking as our example, then, a young individual on the verge of maturity (cf. Fig. 71), we remark at once the great increase in size upon that of the Hylobates skulls. The proportions too of face and cranium are different, the facial part having gained in bulk; to this gain a notable contribution is made by the mandible.

In proportions, the cranial part of the skull is, when contrasted with the facial part, less elongated than in Hylobates, and presents the nearest approach to bra-chycephalic proportions (cf. Chapter XI) met with among the Simiidae. The cranial sutures early become simplified and are closed by synostosis. Traces of the division of the parietal bone into upper and lower halves are stated by Ranke to be very frequent (the trace consisting in a remnant of the dividing suture persistent at its starting point from the coronal suture).

Rapidly converging from the external angular processes of the frontal bone, the tem-poral ridges vary in their ultimate conformation, the sexual element being of im-portance. For in the female
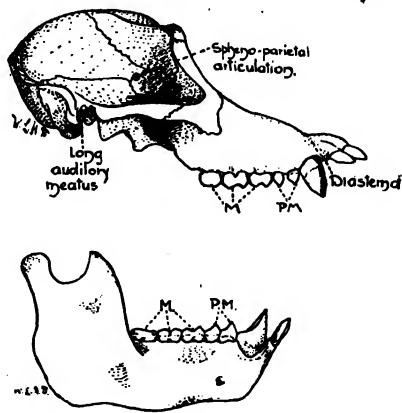
Fig. 71. Cranium (with mandible) of an Orang-utan (Simiidae); note the absolute obliteration of nasal prominence, the absence of an auditory bulla, the presence of a spheno-parietal articulation, and the number of the teeth. The lacrymal and ethmoid bones join on the inner orbital wall with separation of the frontal bone and maxilla.

Orang-utan the ridges may remain separated throughout their

course, or may barely come into contact with one another, whereas in the male animal, not only may the ridges meet, but they may rise in the form of a crest measuring as much as 10 mm. in height. Posteriorly, the temporal ridges vary too, in male examples meeting the superior nuchal line, and forming a lambdoid crest not seen in female skulls.

The orbits have an elliptical contour, and the brow ridges are not (as in the African Simiidae) continuous from side to side of the forehead. The orbital margins are distinct; the lacrymal hamulus vestigial, but there is an elongated lacrymo-ethmoidal suture, for the os planum of the ethmoid though of small vertical extent is somewhat broader anteriorly than elsewhere.

The spheno-maxillary fissure is a mere cleft of small dimensions, the post-orbital wall being in consequence almost complete. The infra-orbital suture rarely persists long on the facial surface. The nasal aperture is pyriform with upwardly directed apex: inferiorly the nasal margins are quite lost, and no nasal spine is seen. The nasal bones are more reduced in size than in any other Primate mammal; usually the conjoined bones form a mere elongated splint, and not infrequently no distinct nasal bones are seen at all: sometimes a small ossicle at the upper margin of the nasal aperture is all that remains; the nasal processes of the maxillae then join each other between the orbits.

The palate is elongated and hypsiloid: the tuber maxillare is variable in development, as is also the post-palatine spine.

The temporal fossa is deep, owing to the bowing outwards of the zygomatic arch and the channelling of the alisphenoid. The latter bone touches the parietal, and thus the Orang-utan agrees with Hylobates and Man and many lower Primates, but differs from the African Simiidae and most of the Catarrhine monkeys: the variations in human skulls in this respect will be described in a subsequent chapter.

The infra-temporal crest is insignificant. At the base of the skull the shallowness of the glenoid fossa is to be remarked. The endoglenoid process or tubercle is small, as is the styloid process, which is often absent. The vaginal process is also absent. Anomalies about the margin of the foramen magnum are rare.

The teeth provide the normal formula, but in males accessory

molar tee...   ...mon. The great length of the
roots of ...   ...d by Tomes (*Dental Anatomy*) as
peculiar:...   ...ation of the enamel (which, though
a featu...   ...oth, persists in the crowns of the
molars ...   ...remarkable. The principal points
of imp...   ...e are its very massive character in
propor...   ...skull ; the ascending ramus, which
is hig...   ...: and which bears a shallow sigmoid
notch...

...   ... OF ANTHROPOPITHECUS NIGER.

...ain...   ...numerated the cranial characters of the
Ch...   ...hecus niger). It may be pointed out
tha...   ...rilla agree in several important respects
wherein they ... ...er from the Orang-utan. This general
statement applies to the skull as well as to other anatomical
structures.

Taking as our example a young, but nearly mature, in-
dividual (Fig. 72), we notice that,
viewed from above, the skull of the
Chimpanzee is more ovoid in form
than than that of the Orang-utan.
The facial skeleton is rather smaller
in proportion to the cranial part than
in either the Orang-utan or the
Gorilla, and here in the Chimpanzee
skull (especially in infancy, cf. Fig.
73) suggests the proportions of the
human skull, though it is still far
from realizing them.

Of the cranial sutures, the sagittal
may be extremely complicated and
tortuous before it becomes closed ; on

Fig. 72. Cranium with man-
dible of a Chimpanzee (Simiidae):
note the absolute obliteration of
nasal prominence, the lack of an
auditory bulla, the presence of
fronto-squamous and fronto-max-
illary (orbital) articulations : note
further the number of the teeth.

the other hand, the straight outline of the suture dividing the
parietal bone from the squamous portion of the temporal bone is
to be noted.

Bony crests occur on the surface of the cranium, but are

comparable rather to those of the C   se of the
Gorilla.   For it is the exception   for the
temporal ridges to form a median s   mmonly
run in close approximation along   verging
thence with the formation of lateral
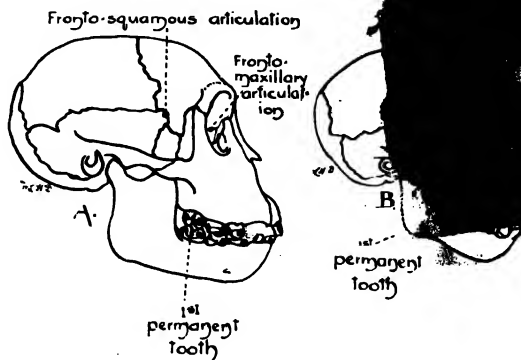
Fig. 73.   Crania, with mandibles, of (A), young Gorilla, and (B) young Chimpanzee (Simiidae).   The first permanent tooth (m) (the first molar) has just been fully acquired in each case, and comparisons can thus be drawn between examples at corresponding stages in development.   Note the greater nasal prominence in the Gorilla ; and the fronto-squamous and the fronto-maxillary (orbital) articulations in both specimens.

The contour of the orbit is less definitely elliptical than in the Orang-utan, and herein the Chimpanzee and Gorilla resemble one another ; similar agreement between the two African apes is seen in the prominence of the external angular processes of the frontal bone, in the continuity of the supra-orbital ridge between these two processes and across the inter-orbital space, in the bevelling of the external orbital margin, and in the shortness of the lacrymo-ethmoidal suture.   The lacrymal hamulus is vestigial, and the spheno-maxillary fissure reduced to a narrow cleft.

The nasal aperture is pyriform, with the truncated apex above ; the lower margins of the aperture are obliterated, and no nasal spine is seen.   The nasal bones are often conjoined at an early epoch, and their flat expanse is not relieved by the very remarkable median ridge so characteristic of these bones in the Gorilla. The nasal bones preserve a more uniform breadth from above downwards than in the Gorilla, and do not extend so far below the

level of the lower orbital margins as in the latter animal. The palate has the characteristic simian hypsiloid contour, and the post-palatine spine is small, as is also the tuber maxillare. Great irregularity of the arrangement of the palatine sutures is frequent.

The temporal fossa owes its depth largely to the channelling of the alisphenoid, which commonly articulates with the frontal and squamosal above, being separated by these two bones, which join at the pterion. The infra-temporal crest is often represented by a single spinous process.

The base of the skull shews the foramen magnum in the position characteristic of Simiidae, i.e. much nearer the occipital end of the skull than in the Hominidae. The glenoid fossa is shallow, with a moderately developed endo-glenoid tubercle, and small post-glenoid process. As in the Gorilla, an Eustachian spinous process is common, but the styloid and vaginal processes are absent. The tympanic bone, as in the other Simiidae, is long and semi-cylindrical in form. The occipital condyles are small and variations in the conformation of the margins of the foramen magnum are rare.

The dentition presents the normal Catarrhine formula: the canine teeth, except in old males, do not so far surpass the other teeth in bulk, as in Simia and Gorilla. In the reduced size of the third upper molar tooth, and in the small size of the cusps of the molar series, anticipations of the human condition are met with. Slight but distinct crenation of the crowns of the molar teeth frequently occurs.

In the development of frontal air-sinuses, and of similar air-cavities in the ethmoid bone, with dilation of the nasal duct, where this is in relation with the maxillary antrum, the Chimpanzee and Gorilla agree, and approximate to the human condition (cf. Keith, *Proc. Anat. Soc.*, 1902), while they differ herein from the Orang-utan and Gibbon.

In concluding these brief descriptions of the external characters of the skulls of Simiidae, it is convenient to present the main points of diagnosis of the several genera in a tabular form as follows:

Distinctive features of the skulls of Simiidae.

I. Hylobates (Gibbon).

Its small size differentiates it from those of other Simiidae. The skulls of Cercopithecidae of similar size are distinguished by their relatively smaller capacity and by the nasal bones (which are longer than in Hylobates). The molar teeth do not possess the two transverse ridges crossing the crown which are so characteristic of the teeth of the lower Anthropoidea.

II. Simia (Orang-utan).

Distinguished by its absolute size from the skull of Hylobates.

Distinctions from Chimpanzee and Gorilla:

(a) The supra-orbital ridge for each orbit is distinct and the two ridges are not continuous across the forehead.

(b) The nasal bones are reduced to mere splints.

(c) The crowns of the molar teeth are crenated so that the cusps are obscured.

(d) The mandible is, relatively to the rest of the skull, of large dimensions.

III. Anthropopithecus (Chimpanzee).

Distinguished by its absolute size from the skull of Hylobates.

Distinctions from Simia are as indicated above.

(a) The supra-orbital ridges are continuous across the forehead.

(b) The nasal bones though flat and short are laminar and not splint-like.

(c) The crowns of the molar teeth bear distinct, but not very large cusps.

(d) The mandible is relatively smaller.

The following are the distinctions between the crania of Chimpanzee and Gorilla.

(a') The skull of the Chimpanzee is smaller, the cranial part is relatively larger, and not characterised by such large ridges as the skull of Gorilla.

(b') The nasal bones are shorter (not extending far below the level of the inferior orbital margins), and their outer margins are more nearly parallel to one another than in Gorilla.

(c') The nasal aperture tends to be pyriform in contour.

(d') The molar teeth are smaller and bear less prominent crowns.

IV. Gorilla.

The skull is distinguished by its actual size from that of Hylobates.

The following are the features distinguishing the skull of the Gorilla from that of the Orang-utan.

(a) As in Anthropopithecus, the supra-orbital ridges are continuous across the forehead.

(b) The nasal bones are splayed and wide, though flat.

(c) The molar teeth bear large cusps.

(d) The cranial ridges are very large.

And the features which differentiate the skulls of the Gorilla and the Chimpanzee are as follows:

(a') The whole skull of the Gorilla is larger: the facial part is relatively larger: the cranial ridges are very large and prominent.

(b') The nasal bones are long, and wide at their inferior margins: they thus end at a level well below that of the inferior orbital margins.

(c') The nasal aperture is ovate rather than pyriform.

(d') The molar teeth bear very large cusps and are larger than in the Chimpanzee.

From external features we pass to those revealed when the skull is sectionized in the median sagittal plane, and the examination of such sections is to be particularly recommended as leading to important conclusions on the essential differences between the skulls of Simiidae and Hominidae.

If the section of a skull of one of the Simiidae thus prepared, be examined (a suitable example is that of a Gorilla, Fig. 4, with which compare Fig. 74, the tracing from an Orang-utan, skull), the following features will at once be noticed in comparison with the corresponding section of a human skull.

Fig. 74.   Tracing from the cranium of an Orang-utan (Simiidae) bisected
in the median sagittal plane.   (Mus. Zool. Cant.)

The relatively great development of the facial skeleton is as evident as when the skull is examined externally.   The characteristic prognathism of the ape is very marked.   The constituent elements of the nasal septum correspond individually to those seen in a similar section of a human skull, the differences consisting in the details of contour and conformation.   In relation with the greater size of the maxilla the system of air-spaces is

more extensive in the simian skull; this is best seen when the nasal septum is removed (or when that section which does not include the septum is examined). The ape will be found to possess extensive sinuses in the sphenoid, ethmoid and maxillary bones, but not in the frontal bone, a point wherein the Orang-utan differs from the African Simiidae (Chimpanzee and Gorilla), which in this respect are more closely allied to man than is the former ape. In the corresponding preparation of the skull of a Gorilla a large bullous dilatation of the nasal duct will be seen projecting into the maxillary antrum, along the roof of which the infra-orbital nerve runs in a bony canal. In the Orang-utan, the part of the frontal which is excavated by the frontal sinuses in the other apes, is a solid mass of bone which may attain a thickness of nearly 20 mm.: seen in section, this thickness is reduced to about a quarter of this amount at the coronal suture, and the latter dimension is retained to the region of the lambdoid suture, where it is increased by the ridge which crosses the skull in a position corresponding to the lambdoid suture in man.

In contrast to the human skull, the bones of the cranial vault thus form an arch of much less bold proportions, and this is perhaps most noticeable at the occipital end of the skull, which gives the impression of having been arrested in development, leaving the occipital arc but slightly curved, and the foramen magnum consequently midway between the posterior and the inferior aspects of the skull.

The endocranial surface bears faint impressions due to the cerebral convolutions[1]; the floccular fossa is not present, and its absence constitutes a difference between the simian and cerco-pithecoid skull. The superior petrosal sinus may be almost completely roofed in by bone, a bony bridge may be formed over the Gasserian ganglion, and the posterior and anterior clinoid processes may be connected by bone: the orbital roof will be seen to rise from the cribriform fossa much more steeply than in the human skull. Continuing the inspection of the sectionized surface, the series of bones forming the base of the skull is next met with: and the basi-occipital, the sphenoid, and ethmoid elements are easily recognisable. The crista galli does not exist in the Simiidae

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[1] Cf. Schwalbe, *L'Anthropologie*, 1904.

as a rule, and certainly is not seen here. Anteriorly, the nasal spine of the frontal bone will be seen to be rudimentary, and in the Orang-utan the superior maxilla may come into the section in place of the nasal bone, as a consequence of the diminutive size, or extent, or of the absence of the latter element. But it is to the arrangement of the ethmoid, sphenoid and basi-occipital elements of the cranial base that special attention must be given.

It will be seen (cf. Figs. 4 and 74) that anteriorly the line of section of the upper margin of the ethmoid forms a plateau, nearly horizontal in direction, and that passing backwards from this, the line of the upper margin of the sphenoid is (with the exception of a hillock representing the section of that portion of the presphenoid which lies between the ' orbito-sphenoids) practically continuous with the clivus, the li sing almost directly to the margin of the foramen magnum t interruption. The point to which attention is drawn is line forms with that of the upper margin of the ethr salient endocranially, open below, and moreover wic oximating to the value of 180°, or two right angle the human skull (cf. Fig. 75) shews the inclination s to be represented by a very much smaller angle. rious ways of measuring this angle, and these w ved in detail in another connection, but for the ll suffice to call attention to the general appear nclusion is, that in the simian skull the basal ly in line, but that in the human skull th inflection constitutes an important peculiarity

Tracing from the c in t m li

If now w he limits of this group of animals, and turn our attention first to the lower Primates, and secondly to other mammals, we shall find that the straightness of the series of basal elements becomes more marked as we descend the series, and that long before we leave the Primates the straightness is interrupted, and that in the following way.

If we suppose the central part of the series of bones, viz. the sphenoid and the basi-occipital (B. Pr., Fig. 75), to be the more fixed portion of the base, then we can describe the condition obtaining in the human skull as one in which the ethmoidal element (Pr. N., Fig. 75) is bent, or inflected, strongly downwards

from the anterior end 'of thi▮▮▮▮▮▮▮▮▮▮▮▮ proceeding
to the simian skull, the appe▮▮▮▮▮▮▮▮▮▮ ethmoidal
element is bent downwards to▮▮▮▮▮▮▮▮▮▮ much less in
fact, that it is almost in line wi▮▮▮▮▮▮▮▮▮on as just defined.
Lastly, when we examine the sk▮▮▮▮▮▮▮ primate form such
as Mycetes (Cebidae), the condition ▮▮▮▮ that the ethmoidal
line is so to speak reflected, or bent, no▮▮▮▮wards, but upwards
(as in the Carnivora; cf. Figs. 75 and 7▮▮▮th regard to the more
fixed element.

We may now turn our attention to the region of the foramen
magnum. This was seen to be place▮▮ the simian skull rather
at the junction of the posterior and in▮▮▮ aspects of the cranium,
than frankly on the inferior aspect as ▮ ▮▮▮

A line (Op. B., Fig. 75) drawn from ▮is th▮▮ior to the posterior
median point on the margin of this the cor▮ represents what is
described as the " plane of the foram▮gion of t▮▮ (Cleland called
it the " posterior base of the skull▮ge which cr▮▮▮ name may be
retained for the moment); the li▮mbdoid suture this plane (and
therefore the plane itself), will ▮▮ the bones of t▮nclined to the
bold proportio▮
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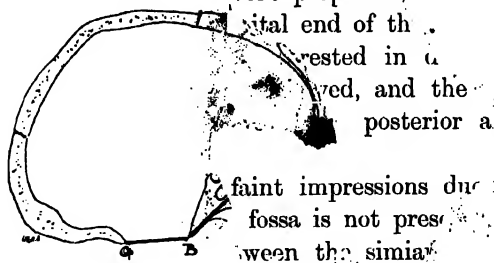
Fig. 75. Cranium of an aboriginal native of Australia (Hominidae) bisected in
the median sagittal plane. N. Pr. represents the anterior or ethmoidal portion of
the cranial base; Pr. B. is the middle or basi-occipito-sphenoidal portion; B. Op.
represents the plane of the foramen magnum.

spheno-basilar or "fixed" portion of the base (B. Pr., Fig. 75), in
such a way that the angle between the two is salient downwards
and backwards (cf. Figs. 4 and 74): moreover in the Simiidae
the angle is a large one (varying from about 120° to 140°).
Turning to the human skull, we find that the mean value is
rather greater (the variations ranging from about 137° to 157°).

But if no ... er Anthropoidea, to the lowlier primate f ... ers, we find that the angle is very much ... ore nearly the value of a right angle; thi ... Cynocephalous monkeys, or in Carnivora ...

We th ... on that in the evolution of the
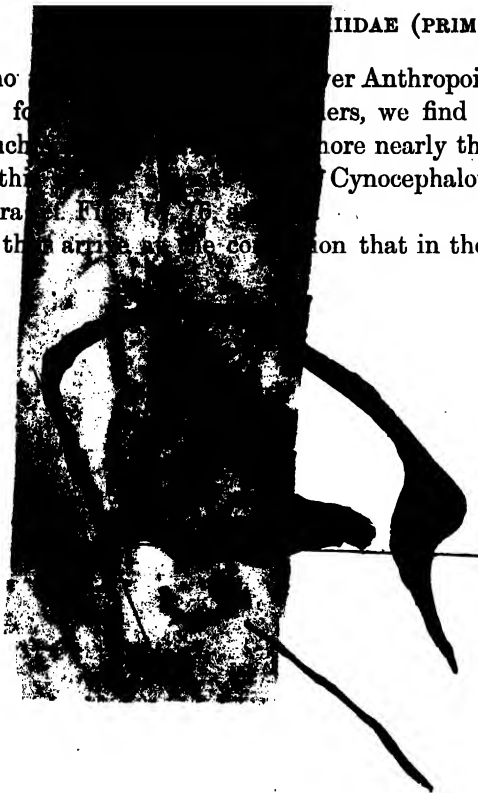
Fig. 76. Cranium of a Baboon (Cercopithecidae) bisected in the median sagittal plane. The lines represent the plane of the foramen magnum, and the cranio-facial axis respectively.
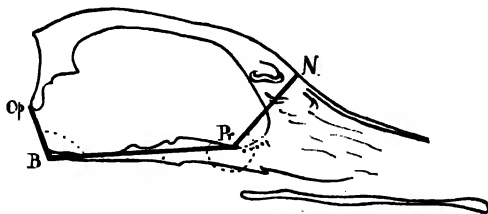
Fig. 77. Cranium of a Dog (Carnivora, Canidae) bisected in the median sagittal plane; to shew the two sections into which the cranio-facial axis has been conventionally divided. The line Op. B. represents the foramen magnum; B. Pr. the "middle base," and Pr. N. the "anterior base."

form of the skull important changes have taken place in the
relations of the anterior and posterior basal portions respectively,
to the intermediate, centrally-placed part.   And that if the latter
be regarded as comparatively fixed, the anterior or ethmoidal part
at one end, and the posterior or foraminal portion at the other,
vary from animal to animal in such a way as to enable one to
compare them to levers fixed at each end of a bar which serves
as a fulcrum to both.   Further, that in the lowliest forms of
the Eutherian skull the conditions may be represented diagram-
matically by supposing each lever to be raised above the (more
or less) horizontally placed middle portion, thus (Fig. 78, with
which compare Fig. 77):
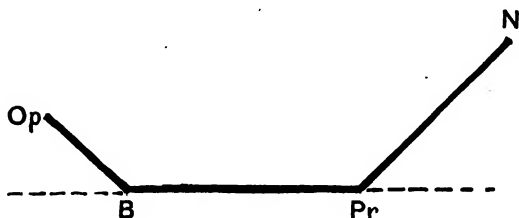
Fig. 78.   This and the three succeeding figures represent the component parts
of the cranial axis in the several stages which mark the path of evolution of the
human type (Fig. 81) from the generalised mammalian type (Fig. 78, with which
cf. Fig. 77).   In the latter (Fig. 78) the line B. Pr. represents the comparatively
stable middle portion, extending from the basion (cf. Chapter x.) to the prosphenion,
or most anterior point of the sphenoid bone.   B. Op. represents the plane of the
foramen magnum; and Pr. N., the line from the prosphenion to the nasion,
represents conventionally the plane of the cribriform fossa.   These indications
apply to the whole series of figures (78—81 inclusive).

We have seen that in the simian skull, both levers have been
depressed to a considerable extent, the anterior, ethmoidal one,
more than the posterior, foraminal one; so that the diagram for
the simian type of skull is as represented in Fig. 79 (with which
compare Fig. 74):
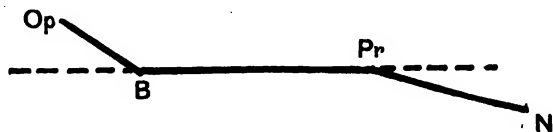
Fig. 79.

or, since the anterior element is now the more nearly horizontal one, thus (Fig. 80):
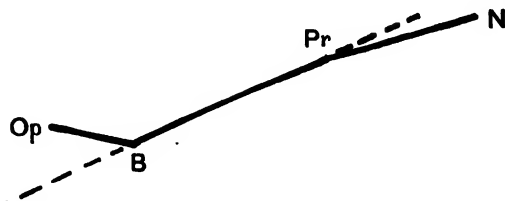
Fig. 80.

while finally, in Man, the condition incipient in the Simiidae has been brought to a further stage, and the appropriate diagram is as shewn in Fig. 81.
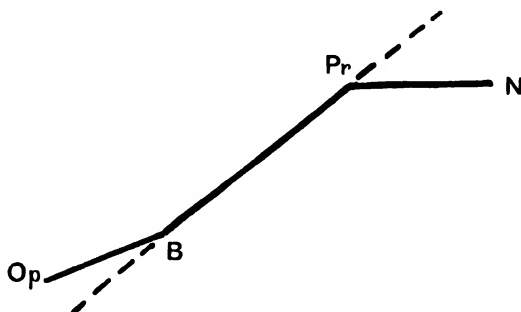
Fig. 81.

It is therefore to be noticed (*a*), that the human skull is characterized by the *degree* of flexion of these anterior and posterior elements upon that part of the base which lies between them; (*b*), that the simian skull indicates this change in an incipient stage, and is thus anticipatory of the human skull[1].

Such then are the chief features of interest in the sectionized skull, and their enumeration and description may be not unfitly

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[1] In the foregoing account an attempt has been made to give a general description only of the essential features of the cranial base, and of the changes which are seen in its evolution. No reference has been therefore made to exact angular measurements; nor to the exact details of procedure that should be followed in drawing the lines by which such angles are included. Nor has special reference been made to the cranio-facial axis as such: this would have necessitated reference to the nasal bones with consequent complication of the description.

followed by an indication of their significance. Assuming that the conformation of the cranium is largely expressive of the conformation and development of the encephalon which it encloses, it is to the latter that an appeal must be made in elucidating the differences in the several crania investigated. Nor will the appeal be made in vain. For in the lowly Mammal and lowly Primate, the encephalon is still, in the great majority of cases, relatively small, and the cerebral hemispheres have not assumed the exuberance of growth which is a characteristic of the higher forms. When this tendency to cerebral growth has been initiated, it is found that the inferior aspect of the cerebrum, the base of the brain, the floor of the third ventricle and the allied and adjacent structures, remain comparatively passive, while the cerebral hemispheres tend to expand in all directions, anteriorly, posteriorly, and laterally, upwards and downwards.

A glance at the series of diagrams of the sections of skulls will shew how such expansion implies pressure in those directions; acting anteriorly, this will force the cribriform fossa first forwards and ultimately downwards, the transition being capable of representation by the movement of the anterior lever of our diagram (Pr. N., Fig. 78, p. 117), the active force being indeed the intrinsic cerebral growth. Posteriorly, similar expansion drives backwards and then downwards the occipital wall of the cranium, and with it the foramen magnum in a similar way, capable too of similar representation (see Figs. 78 to 81 incl., pp. 117 and 118).

Expansion upwards produces the bold vaulting of the cranial arc, and in all these respects it is to the human cranium that we are led by the successive stages assumed in the lower and higher quadrupedal monkeys respectively, and in the Simiidae themselves. In Man the effect is at a maximum, the lower Primates merely suggesting the development that is to be.

A few remarks may now be made in conclusion of this part of our subject. Viewed in this light, we see how the study of skulls of various mammals gives us guidance as to their cerebral or encephalic conformation. Hence the study of the osteology of living forms is of paramount importance with respect to the study of extinct forms, of which only the skeletal parts remain. Secondly, there remains a word of warning as to the "fixity" of

the central part of the base of the skull. This fixity is not absolute, for even this central portion participates in the flexion consequent on the pressure of the rapidly enlarging brain. But for the purposes of description, and for the general realization of the circumstances attendant on the evolution of the characteristic form in the Simiidae and Man, it is justifiable to neglect this secondary change. Finally, the impression left on one's mind by the study of the cranial osteology of these large apes (and the same remark applies to other departments of their anatomical structure), is that they are evidently examples of highly specialised Primates. So evident indeed is this, that a table can be drawn up to shew that there are not lacking features in which the Simiidae even surpass the Hominidae in point of morphological specialization. And while it is inappropriate to enter further upon this subject here, the table may be of interest as illustrative of the point in question.

TABLE.

In comparison with the crania of Simiidae, the human skull will be seen to be more highly specialised and to have departed further from the generalised type in point of such features as:

(1)   Inflection of the basis cranii.
(2)   Forward position of the foramen magnum (cf. Fig. 82).
(3)   Diminished proportions of the maxilla.
(4)   Early and complete fusion of the premaxilla and maxilla.
(5)   Large ascending mandibular ramus, and coronoid process with a deep sigmoid notch behind it.
(6)   Prominence of the chin.
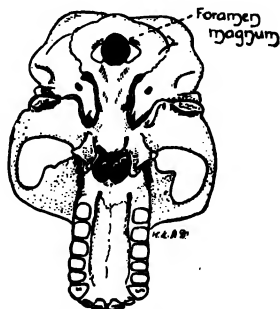
Fig. 82. Basis cranii of an Orang-utan, shewing the position of the foramen magnum, far back in contrast with its position in the human skull. Fig. 75 should also be compared with Fig. 77, when the same contrast will be observed.

On the other hand, the following features may be claimed

as shewing that the human skull is therein more generalized
and primitive than those of the Simiidae.

(1)   Lack of bony ridges.
(2)   Large nasal bones.
(3)   Wide spheno-maxillary fissure.
(4)   Articulation of parietal and sphenoid bones at the
        pterion[1].
(5)   Articulation of lacrymal and ethmoidal bones in the
        orbit[1].
(6)   Uniformity in the size of the teeth.

It should be understood however, that these lists are not
exhaustive.

[1] The contrast is in this instance with the African Simiidae only.

CHAPTER VI.

THE DENTAL SYSTEM OF THE PRIMATES.

In enumerating the methods of investigation which have proved of assistance in elucidating the ancestral history of existing animal forms, reference was made to the study of fossil remains. From the nature of their constitution, the teeth are particularly apt to be preserved in the fossil condition, and for this reason the study of the characters of teeth claims special attention in connection with investigations undertaken with the object cited above. For the same reason it is appropriate to review, even though very briefly, the normal features of the teeth in the more representative members of the Primates, and besides the palaeontological interest of this study, another claim is presented, in view of the inferences that may be drawn from the direct morphological comparison of the several animals subjected to such an enquiry. The following notes will therefore deal in succession with the main dental characters of representatives of the Lemuridae, of the Cebidae, Cercopithecidae, Simiidae, and Hominidae; of these the canine and post-canine teeth will first be considered, and subsequently the characters of the incisor teeth will be briefly indicated[1], the permanent and not the transitory teeth being in all cases considered.

A. THE CANINE AND POST-CANINE TEETH.

LEMUROIDEA. LEMURIDAE. LEMUR VARIUS (cf. Fig. 18).

Dental formula : i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{3}{3}$; m, $\frac{3}{3}$;

The upper teeth: Fig. 83. The canine tooth is remarkably large with a

[1] The following figures (Nos. 83 to 107 inclusive) represent the several teeth in their natural proportions, without reduction.

trenchant posterior margin : its socket is separated by a distinct interval from the lateral incisor in front of it (diastema), and from the premolar behind it. The premolar teeth are three in number, and increase in size from before backwards ; the first is very small with a relatively immense, sharp, central cusp, supplemented by minute anterior and posterior cusps. The second premolar tooth is larger, the central cusp still immense, and an internal cusp is suggested on the surface of the cingulum (a band which surrounds the base of the tooth crown) ; in the third premolar tooth this internal cusp is still more marked. The molar teeth are tricuspid (or tritubercular, cf. p. 146) and the cingulum is distinct, forming internally a prominent band which skirts
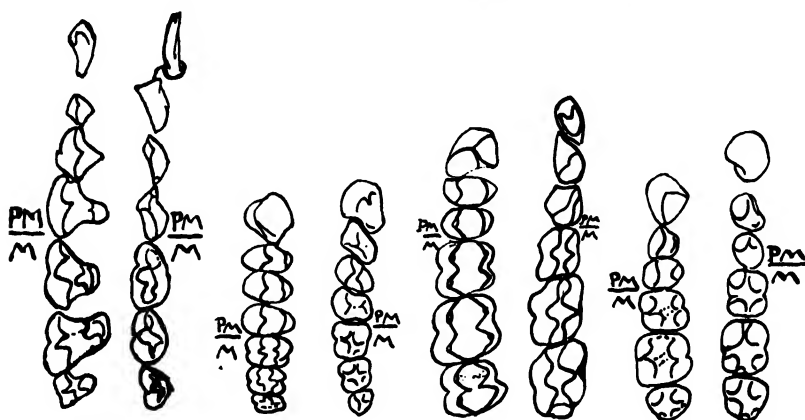
Figs. 83   84   85   86   87   88   89   90

Fig. 83. Right upper canine and post-canine teeth of a Lemur. (No. 4, Mus. Zool. Cant.)

Fig. 84. Left lower canine and post-canine teeth of a Lemur. (No. 4, Mus. Zool. Cant.)

Fig. 85. Right upper canine and post-canine teeth of Cebus capucinus. (No. 1093, Mus. Zool. Cant.)

Fig. 86. Left lower canine and post-canine teeth of Cebus capucinus. (No. 1093, Mus. Zool. Cant.)

Fig. 87. Right upper canine and post-canine teeth of a Macacus monkey. (Cercopithecidae.)

Fig. 88. Left lower canine and post-canine teeth of a Macacus monkey. (Cercopithecidae.)

Fig. 89. Right upper canine and post-canine teeth of Hylobates mülleri. (W.L.H.D. priv. coll.)

Fig. 90. Left lower canine and post-canine teeth of Hylobates mülleri. (W.L.H.D. priv. coll.)

the inner of the three cusps ; the other two cusps are external (cf. Fig. 83). The third and last molar tooth is much smaller than the second, and as this is smaller than the first, the series diminishes backwards in size.   In the mandible (Fig. 84) the formula (*v. supra*) requires some elucidation, for the canine tooth (judged by the formula) is apparently incisor-like in form, and it is also procumbent, or directed horizontally forwards like the definite incisor teeth (*v. infra*, p. 133).   Moreover, the first premolar tooth resembles a canine tooth.   The question of the identification of these teeth is still in doubt ; Forsyth-Major (*Geological Magazine*, 1900) has adopted the view which regards the canine-like tooth as the genuine canine, and the outer incisor-like tooth as an incisor, thus providing the mandible with a dental formula i, 3; c, 1 ; pm, 2 ; m, 3 ; different, that is, from the maxillary formula i, 2; c, 1 ; pm, 3 ; m, 3.   But it is to be noticed that against this view may be urged the fact that the canine-like premolar tooth although admittedly canine in form, yet closes in the bite posteriorly, and not anteriorly, to the upper undoubted canine tooth.   Now this posterior position of a lower canine tooth is a phenomenon of extreme rarity, and though Forsyth-Major defends his position by appealing to the progressive shortening of the mandible, which no doubt has occurred, still in view of the mutability of dental forms, it seems more consistent to adopt the opposite view of regarding the canine tooth of the mandible as incisiform, and the first premolar tooth as caniniform[1].

All the mandibular teeth are flattened from side to side, the premolars bear one relatively immense cusp and three minute subsidiary cusps, cf. Fig. 91, and the middle premolar tooth is the smallest of the three.   The molar teeth are quadricuspid, the two cusps being external and larger than the two remaining and internally situated cusps, and these teeth diminish in size backwards. Such diminution backwards suggests that the jaws are undergoing a process of reduction in

Fig. 91.   Enlarged view of the lower premolar tooth of a Lemur (W.L.H.D.).

length which is in operation at the posterior extremity.   In addition to this, Forsyth-Major has pointed out that retraction of the mandible as a whole has occurred.

Nycticebus (Lemuridae).   In this form (as in the slender Loris) the molar teeth of the upper jaw are four-cusped, the cusps being arranged in two pairs, with an oblique ridge joining the antero-internal to the postero-external cusp. This arrangement is met with rarely among the Cebidae, entirely lost in the Cercopithecidae, but reappears in the Simiidae and Hominidae, of the dentition of which families it is a marked feature.

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[1] Flower and Lydekker, *Mammals*, p. 683, suggest that the canine tooth is absent altogether.

ANTHROPOIDEA.   CEBIDAE.   CEBUS CAPUCINUS.

Dental formula of the family: i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{3}{3}$; m, $\frac{3}{3}$.

The upper teeth: the canine teeth (Fig. 85) are relatively enormous in size, especially in the male sex (cf. Fig. 21); the post-canine teeth present a feature of marked contrast with the corresponding teeth of the Lemuridae, inasmuch as the crowns appear much reduced in the antero-posterior direction (this is even more distinct when the lower series are compared, cf. Figs 84 and 86). A diastema is present. The premolar teeth are three in number and bicuspid, with anterior and posterior cusps: in size they diminish progressively backwards. Of the three molar teeth, the first is the largest and the diminution in size backwards is very rapid, the last tooth being minute. The molar teeth bear four cusps, two outer and two inner, and in the species under consideration (C. capucinus) no connecting ridges are seen. In some forms the antero-internal and postero-external cusps may be connected by an oblique ridge (cf. Fig. 118).

The lower canine teeth correspond to the upper teeth in size, and close anteriorly to these as in the great majority of Eutheria. The first of the three premolar teeth is pyramidal and suggests a transition from the canine form to the bicuspid premolar form: it bears one predominant cusp and a second smaller cusp, and is distinctly larger than the two remaining premolar teeth, which are bicuspid with external and internal cusps, and sub-equal in size. The three molar teeth diminish rapidly in bulk backwards, the last being clearly degenerate, and this degeneracy in the third molar teeth of the otherwise comparatively primitive Cebidae must be insisted on. Such reduction is again met with in the Simiidae and Hominidae, but must not be regarded as confined to these higher families of the Primates. The molar teeth bear three distinct cusps, two external and one antero-internal, the postero-internal cusp being quite indistinct, especially in the last tooth. The three better marked cusps are connected by rather indistinct ridges[1].

ANTHROPOIDEA.   CERCOPITHECIDAE.   MACACUS RHESUS.

Dental formula: i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{2}{2}$; m, $\frac{3}{3}$.   (Figs. 87 and 88.)

The canine teeth, which may in male specimens attain very great dimensions (cf. Fig. 28) are preceded in the upper jaw by a distinct diastema. The upper premolar teeth (two in number) are bicuspid but are implanted by three roots. (In the types hitherto considered, the number of roots of the premolar teeth has varied; in some teeth the root is single and in others even

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[1] The indistinctness of the postero-internal cusp is important. As will be shewn later (in Chapter xvi) the indistinctness of a particular cusp has been appealed to in support of a particular view concerning the fossil Pithecanthropus erectus. The point therein raised is that in the lower Primates, the reduction in cusps affects the postero-external before it modifies the postero-internal cusp (while in the Hominidae the postero-internal is the first of the two to shew signs of reduction). But the incompleteness of this generalization is clearly shewn by the foregoing observation.

in the same jaw, three roots being present.) As in Cebus the premolar crowns
shew signs of antero-posterior flattening, the outer cusp of the first tooth is
much larger than the inner and the two teeth are nearly equal in size.   The
upper molars bear four cusps, two external (buccal) and two internal (lingual)
united in pairs by transverse ridges, and implanted by three roots.   The
second tooth is the largest, the first and third being nearly equal in size,
though the latter may be in some instances reduced.   There is no distinct indi-
cation of reduction of cusps in the third molar tooth.   The lower canine tooth
corresponds in dimensions to the upper, and the first lower premolar tooth is
caniniform, the lingual (internal) cusp being quite overshadowed by the
hypertrophied external cusp.   As in all the lower post-canine teeth the roots
are two in number, and the same teeth preserve the lemurine feature of
lateral compression, though this is only marked in the first premolar tooth.

The three molar teeth increase in size progressively backwards : their
crowns bear four cusps united in pairs by transverse ridges, and in the last
teeth the posterior projection known as the "talon" is well developed and
bears one or even two subsidiary cusps.

As will be explained later (p. 149) stress has been laid on the presence of
the transverse ridges upon the crowns of the molar teeth (whether upper or
lower) of the Cercopithecidae, to the exclusion of an oblique ridge.

ANTHROPOIDEA. SIMIIDAE. HYLOBATES MÜLLERI : a Gibbon
from Borneo.

Dental formula : i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{2}{2}$; m, $\frac{3}{3}$.   (Figs. 89 and 90.)

The upper teeth.   The canine teeth are very long and slender (cf.
Fig. 70) and preceded by the diastema.   The premolars are bicuspid
with three roots, and the first of the two is caniniform in so far as
the outer cusp is much larger than the inner, the latter being very
obviously a derivative of the cingulum.   In the second premolar tooth
this disparity is less distinct, and this tooth is rather larger than the first.
The three molar teeth decrease in size progressively backwards.   Like the
premolar teeth, they are implanted by three roots, two external and one in-
ternal, and their crowns bear four cusps, two external (lingual) and two
internal (buccal) in position.   It is important to note that these cusps lack
the transverse connecting ridges which are so characteristic of Cercopithecidae,
but which are here replaced by an oblique ridge uniting the antero-internal
with the postero-external cusp.   The significance of this will be discussed in
another connection (cf. p. 149).   The third molar tooth bears signs of degene-
ration, two posterior (lingual and labial) cusps and the oblique ridge being in
some cases vestigial and indistinct.   The lower teeth (Fig. 90) situated behind
the canine tooth are implanted by two roots each, these roots being anterior
and posterior in position as is the general rule in the Primates.   The lower
and upper canine teeth correspond in development, and it is noteworthy that
traces of lateral compression are perceptible in these teeth.

The post-canine teeth still present signs of the same lateral compression though this feature is less conspicuous than in the Lemurs and even the Cercopithecidae ; for a process of antero-posterior reduction is now being initiated, with the result of rendering the crowns of the teeth equilateral in proportions.

The first of the two premolar teeth (cf. Fig. 89) bears one very large (lingual) and a much smaller (labial) cusp; it is larger than the succeeding tooth, the crown of which is furnished with two small cusps, behind which an undoubted though minute talon is seen.

The lower molar teeth vary in different specimens, but the second tooth would seem to be the largest, next to this the first, though this and the third are in some cases equal in bulk. The crowns bear four or five cusps ; viz. an anterior pair (external and internal) which may be connected by a transverse ridge[1] ; and a posterior pair not so connected, and between which a fifth minute cusp may be seen : the last-mentioned cusp may be regarded as representing in a reduced form the bicuspid talon, so conspicuous in the Cercopithecidae (q.v. p. 126). Finally, it should be noted that in the reduction affecting these cusps, the inner (lingual) posterior cusp is involved to a greater extent than the outer. This affects a point of controversy to which attention has already (p. 125, footnote) been drawn.

ANTHROPOIDEA. SIMIIDAE. SIMIA SATYRUS (Orang-utan).

Dental formula : cf. Hylobates. (Figs. 92 and 93.)

In correspondence with the greater absolute bulk of these animals the teeth of the larger Simiidae are larger than any others hitherto considered. As in most of the Anthropoidea, the sexual factor has an important influence upon the dentition and particularly upon the dimensions of the canine teeth. The transitory dentition is found in all the Primates so far as they are known ; in the case of the higher members of this Order (cf. Figs. 32 and 73) a very close agreement with the phenomena presented by the Hominidae has been observed, and in the larger Simiidae the transitory teeth correspond in number to those found in the milk dentition of the Hominidae. The differences hitherto noticed affect the sequence in which the replacement of the transitory by the permanent teeth occurs.

To return to the teeth of the Orang-utan, we note (cf. Fig. 71) a large diastema or interval in front of the upper canine teeth : the two upper premolar teeth resemble one another more closely than in some forms previously dealt with (e.g. Cercopithecidae). Both are bicuspid and furnished with three roots ; in both the antero-posterior diameter of the crown is diminished : in the first of the two, the outer or labial cusp surpasses in size the lingual cusp. Like the remaining post-canine teeth, the crowns of the premolar teeth are marked with fine crenations.

[1] This is seen in a specimen in the writer's possession.

The crowns of the three molar teeth exhibit crenate markings in a degree which is peculiar to the Orang-utan among the Simiidae and in which it
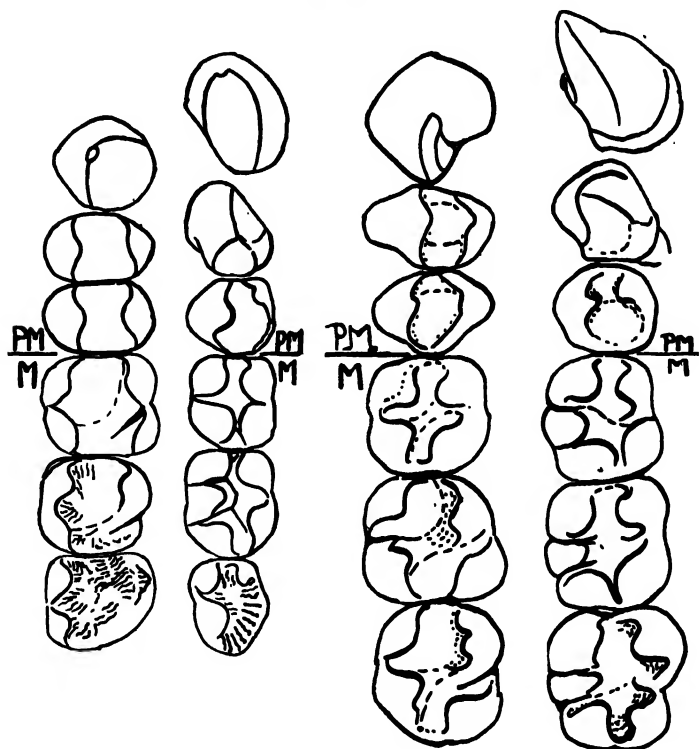
Figs.   92.   93.   94.   95.

Fig. 92.   Right upper canine and post-canine teeth of an Orang-utan (ad. ♂ W.L.H.D. priv. coll.).

Fig. 93.   Left lower canine and post-canine teeth of an Orang-utan (ad. ♂ W.L.H.D. priv. coll.).

Fig. 94.   Right upper canine and post-canine teeth of a Gorilla (ad. ♂ W.L.H.D. priv. coll.).

Fig. 95.   Left lower canine and post-canine teeth of a Gorilla (ad. ♂ W.L.H.D. priv. coll.).

is most nearly approached by the Chimpanzee.   This crenation is the expression of folding of the enamel covering the crown and is a feature of practically all developing molars in the Primates.   Its persistence thus constitutes the retention of an embryonic condition.   When strongly marked,

and individuals present much variation in this respect, the features of the dental crown are hereby obscured. Nevertheless it is possible to make out some other points in the conformation of these teeth. The crowns are nearly equilateral and traces of four cusps are commonly seen. The first and third molar teeth are nearly equal in size and both are smaller than the second : the last tooth seldom fails to bear signs of degeneration. Of the cusps, the antero-internal and postero-external are joined by an oblique ridge similar to that seen in Hylobates. The postero-internal cusp shews signs of degeneration and reduction (it may be replaced by several minute eminences) before these are exhibited by the other cusps.

The lower canine tooth is long and tusk-like. The first premolar tooth is pyramidal, and the labial cusp far surpasses the lingual cusp in size. The two cusps of the second premolar tooth are subequal in size, and a suggestion of a posterior projection, or talon, is seen as in Hylobates. Crenation is seen as in the upper post-canine series.

The molar teeth are longer than they are wide, the last tooth being the smallest. The cusps are five in number, and the posterior intermediate cusp is often found to be much reduced in prominence in the last tooth.

In the Orang-utans supernumerary molar teeth are extraordinarily frequent, and particularly so in the male sex : the additional tooth is usually placed behind the third molar. This subject will be further discussed in connection with anomalies of the dentition (p. 138). The great length of the roots of all the teeth has been remarked as a characteristic feature of the dentition of the Orang-utan (cf. Tomes, *Dental Anatomy*, ed. 1898), while reference to Figs. 92 and 93 shews that the Orang-utan provides an excellent illustration of the comparatively gradual transition and transformation from one type of tooth to another. (*v. infra*, p. 143.)

ANTHROPOIDEA. Simiidae. Gorilla savagii.

Dental formula : i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{2}{2}$; m, $\frac{3}{3}$. (Figs. 94 and 95.)

In the replacement of the deciduous (milk) teeth by those of the permanent series it is to be noticed that whereas in the Hominidae the canine teeth are replaced before the third molar tooth appears, yet in Gorilla these events occur in the reverse order. In the male Gorilla (adult) the canine teeth are enormously developed and the diastema is very evident. The upper premolar teeth bear two cusps, labial and lingual in position, but it is to be remarked that suggestions of two other cusps of minute size, situated behind these, are not uncommonly present. The labial cusps are the larger. The premolar teeth have three roots. The molar teeth are quadricuspid and the cusps stand out with peculiar distinctness : the oblique ridge joining the antero-internal and postero-external cusps is likewise unmistakeable. Measurements of a number of specimens shew that the last molar tooth is smaller than the first, the second being the largest of the three ; so that the reduction that has been so often noticed in this tooth

is present in the dentition of Gorilla. The molar teeth are implanted by three divergent roots.

The lower premolar teeth differ not a little in appearance from one another. The first is pyramidal and bears one well-defined cusp: in the second tooth the two cusps are nearly equal in size, and behind them a small talon projects. The molars are comparatively narrow, and elongated antero-posteriorly: they commonly bear five cusps, the anterior pair of which are to some extent united, and at the same time leave the three posterior cusps isolated from one another. In some cases as many as six cusps may be seen, the posterior talon bearing two of these. No confirmation appears to be given to the statement that the postero-external cusp is earlier affected by degenerated processes than the postero-internal cusp. (*v. ante* p. 125, footnote.) While the statement (cf. Topinard, quoted by Fraipont, *Archives de Biologie*, VII. p. 735) as to the progressive increase backwards in the size of molar teeth does not hold good in the upper series, there is no doubt that it is true of the lower teeth[1].

ANTHROPOIDEA. SIMIIDAE. ANTHROPOPITHECUS NIGER.

Dental formula : i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{2}{2}$; m, $\frac{3}{3}$. (Figs. 96 and 97.)

As regards the canine teeth similar remarks apply to the Chimpanzee and Orang-utan. The upper premolar teeth, and indeed the whole dentition, of the Chimpanzee suggest however the human dentition much more distinctly than does that of any other Primate. Shortening of the maxillae has evidently to be recognised, and the crowns of the premolar teeth, when compared with those of Gorilla, are much reduced in the sagittal direction. These teeth bear outer and inner cusps, while as regards roots a difference may obtain, the first premolar tooth possessing three roots, the second tooth having only two.

The molars present a crown of equilateral proportions, the third tooth being degenerate both in size and in the reduction of the posterior cusps, of which the postero-external may be more affected than the postero-internal cusp. (Thus confirmation of the statement to which reference has been made already, is provided by one of the Simiidae only.) The other molar teeth bear four cusps, viz., an anterior and a posterior pair, the characteristic oblique ridge being present as in the other Simiidae. And it is to be remarked that crenation is often distinct, though less characteristic of the Chimpanzee than of the Orang-utan. In the mandible, the premolar teeth are less like the corresponding human teeth than when the comparison is made with teeth of the upper series. For in the mandible the characters of the premolar teeth in Chimpanzee are very similar to those of the same

[1] The latter statement as well as that made in reference to the relative sizes of the molar teeth in the Orang-utan is based upon the results of measurement in adult examples. Five male Gorillas and six male Orang-utans were available.

teeth in Gorilla, being distinguished chiefly by their smaller size and the persistence of crenate markings. Very similar remarks apply to the lower molar teeth, viz., that they resemble the corresponding teeth in Gorilla, but present crenate foldings of the enamel, and are less elongated in the antero-posterior direction.
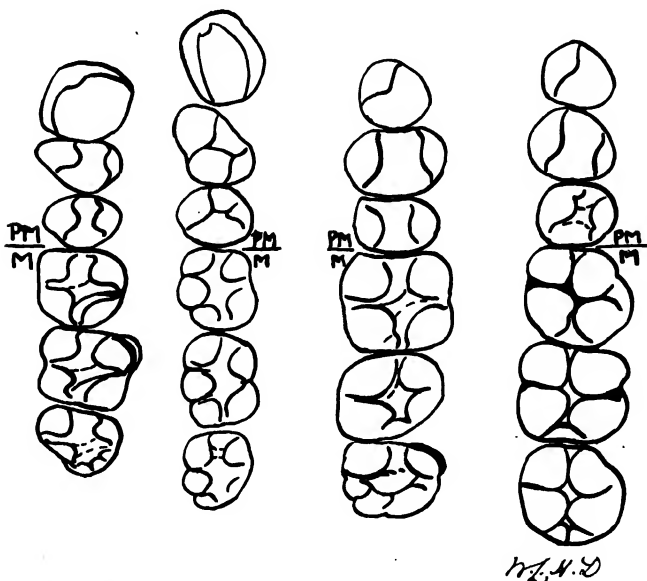
Figs. 96.   97.   98.   99.

Fig. 96.   Right upper canine and post-canine teeth of a Chimpanzee (ad. ♂. W.L.H.D. priv. coll.).

Fig. 97.   Left lower canine and post-canine teeth of a Chimpanzee (ad. ♂. W.L.H.D. priv. coll.).

Fig. 98.   Right upper canine and post-canine teeth of an aboriginal native of Australia (Mus. Anat. Cant.).

Fig. 99.   Left lower canine and post-canine teeth of an aboriginal native of Australia (Mus. Anat. Cant.).

ANTHROPOIDEA.   HOMINIDAE.   HOMO SAPIENS.

Dental formula as in all the Catarrhine Primates : i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{2}{2}$; m, $\frac{3}{3}$. (Figs. 98, 99.)

It has been already remarked that the dentition of the Chimpanzee provides in many ways a transition from the simian to the human modification of the Primate type. When the human dentition is examined in series with those of the other Primates, perhaps the most striking and peculiar feature is the reduction in size of such teeth as are situated anteriorly to the molars,

viz., the premolars, canines, and incisors. Such reduction is doubtless associated with the change in function determined by the greater freedom of the upper limb in man, whereby the jaws are relieved, to a larger extent than in any other Primate animal, of their prehensile function. So too the distinctive characters of the dentition are correlated with the modifications of the cranial base to which reference has been made in the preceding chapter.

The canine teeth have almost entirely lost the predominance in size that obtains in the majority of the Primates: and the diastema is no longer present.

The upper premolar teeth are bicuspid and possess two roots, the molar teeth being furnished with three roots, which are however in the majority of the Hominidae, not divergent, but parallel, and in the third molar may be reduced to two, which may even be fused into a single peg-like root.

The molar teeth do not present crenate markings in the adult: in size, the second upper tooth is the largest, next to this the first molar tooth, while the last tooth is practically always degenerate, and may be absent. The upper molar cusps are four in number, disposed as in the Simiidae but commonly less prominent. The oblique ridge is distinct in the two foremost teeth, but often obscure, or absent from the last tooth.

In the mandible the first premolar is often nearly as large as the canine tooth, and larger than the second premolar tooth: both are bicuspid and furnished like the molar teeth with two roots. The molar teeth present varying relations in point of size: the last is often the smallest of the three; in form the crowns are less elongated in the antero-posterior direction than are the corresponding teeth in Gorilla or Anthropopithecus. The cusps are commonly four in number, and they are distinct, the separating lines forming a crucial fissure. But in many cases, and particularly among the primitive and prognathous coloured races, a fifth cusp is found usually on the posterior margin and between the two normal cusps.

The comparison of the length of the post-canine series of teeth has been studied by Flower (cf. the *Journal of the Anthrop. Institute*, 1885), who devised an index for comparative purposes: this dental index is based on the relation of the dental length (that is the combined lengths of the crowns of the post-canine teeth) to the length of the craniofacial axis.

The index is arrived at from the formula:

$$\text{Dental index} = \frac{\text{length of the premolar and molar crowns} \times 100}{\text{basi-nasal cranial length}},$$

and crania are classified according to the numerical value of that index. Thus the limits of the class divisions are at 42 and 44. Crania with dental indices of a greater numerical value than 44 are recognised as megadont, and such crania are found to prevail in the Oceanic-negro races, while when a comparison is made with the Simiidae, these too (with the exception of Hylobates, and perhaps only in individual examples of these) are very dis-

tinctly megadont, the average value of the index far exceeding 44 and rising to 54 or more.   (For other data cf. Chapter XIV.)

B.   THE INCISOR TEETH.

The formula throughout the Primates is i, $\frac{2}{2}$; they are borne by the premaxilla in the upper jaw.

LEMUROIDEA. LEMURIDAE. LEMUR VARIUS.   Fig. 100.

The characteristic features of the incisor teeth of the Lemuridae are as follows : (*a*) the upper teeth are extremely small (cf. also the extinct Lemurs, e.g. Megaladapis madagascarensis, Chapter XVII.), and the median teeth are separated by a wide gap in the middle line of the face; (*b*) the lower teeth are larger and curiously styloid, they are also procumbent, that is, they are
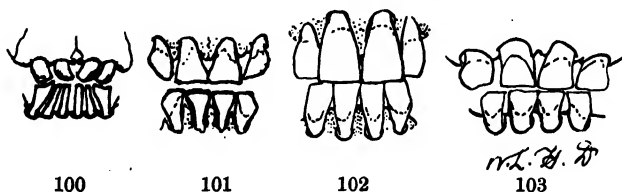
| Figs. | 100 | 101 | 102 | 103 |

Fig. 100. Incisor teeth of a Lemur.   (No. 4, Mus. Zool. Cant.)
Fig. 101. Incisor teeth of Cebus capucinus.   (No. 1093, Mus. Zool. Cant.)
Fig. 102. Incisor teeth of a Macacus monkey.
Fig. 103. Incisor teeth of Hylobates mülleri.   (ad. ♂. W.L.H.D. priv. coll.)

directed almost horizontally forward from the mandible and cannot therefore be of much use as incisor teeth in the ordinary acceptation of the term ; (*c*) the apparent occurrence of three incisor teeth on each side in the mandible is explained by the view which regards the lower canine teeth as having assumed the morphological characters and the position of lower incisor teeth (it will be remembered, *v. ante*, p. 124, that the succeeding tooth, the first premolar, has to some extent replaced the normal lower canine teeth).

ANTHROPOIDEA. CEBIDAE. CEBUS CAPUCINUS.   Fig. 101.

In the Cebidae the disparity in size between the upper and lower incisor teeth (as described in the Lemuridae) is not to be seen, but there is still a slight tendency (quite distinct in Pithecia) to procumbency in the lower incisors (cf. Fig. 21).

The median teeth are provided with chisel-shaped crowns, the lateral with conical crowns : the latter crowns when worn down by use quickly assume a chisel-like edge, but in the unworn condition their frame is as described.

These remarks regarding the crowns of the teeth apply to the Cercopithecidae, and to Hylobates, Simia, and Gorilla, but not to Anthropopithecus or to the Hominidae.

The combined upper series is wider than the lower set. Of the upper four teeth, it is to be remarked that no median gap remains and that the outer (lateral) teeth are smaller than the median pair, while the outer angle of the crown is more open in the lateral than in the median teeth. Of the lower teeth the lateral surpass the median pair in size.

ANTHROPOIDEA. CERCOPITHECIDAE. CERCOPITHECUS. Fig. 102.

The lower incisor teeth are still less forwardly inclined in the Cerco-pithecidae (cf. Fig. 28); the upper median incisors, as in all the Anthropoidea, are in contact and the upper median teeth much surpass the lateral teeth in size. The median and lateral lower incisor teeth are nearly equal in bulk, the lateral pair being rather stouter than the median.

ANTHROPOIDEA. SIMIIDAE. HYLOBATES (mülleri). Fig. 103.

The incisor teeth have the general characters of those of Cercopithecidae. It is to be noticed as a difference (cf. Fig. 102 with Fig. 103) that in the latter the crown is much more extensive in the vertical direction, both absolutely and relatively. The comparative smallness of the crown is seen again in the Orang-utan.

ANTHROPOIDEA. SIMIIDAE. SIMIA SATYRUS (Orang-utan). Fig. 104.

The median upper incisors far surpass the lateral incisor teeth in size : the small size of the upper crowns is very remarkable. Of the lower teeth the median pair exceed the lateral pair in bulk.
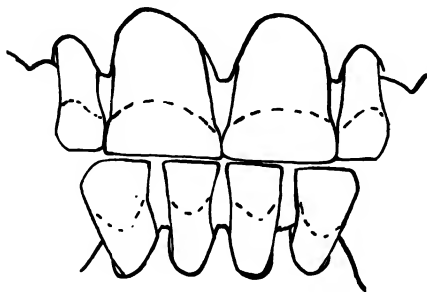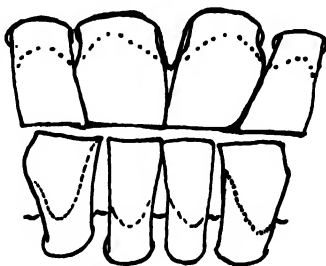
Fig. 104.   Fig. 105.

Fig. 104. Incisor teeth of an Orang-utan. (ad. ♂. W.L.H.D. priv. coll.)
Fig. 105. Incisor teeth of a Gorilla. (ad. ♂. W.L.H.D. priv. coll.)

ANTHROPOIDEA. Simiidaé. Gorilla savagii. Fig. 105.

The difference in the sizes of the median and lateral upper incisor teeth is less marked in the Gorilla, but the median pair are still the larger.   In the lower series the opposite proportion obtains.   The upper crowns are more extensive than in Hylobates and Simia, and recall the type found in Cercopithecidae.

ANTHROPOIDEA. Simiidae. Anthropopithecus niger. Fig. 106.

The upper median teeth are larger than the upper lateral teeth ; the crowns are extensive as in Gorilla; of the lower teeth, the median and lateral pair are nearly equal in bulk.   It is very noteworthy that in the Chimpanzees, the incisor teeth may often equal or even surpass in bulk the incisor teeth of the male Gorilla, while the molar teeth and indeed the whole skull of the Chimpanzee is much smaller than that of the male Gorilla.
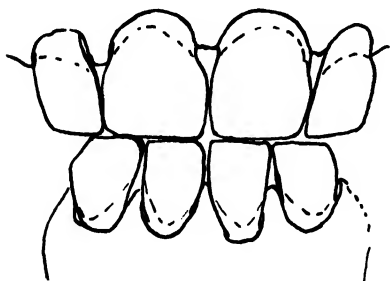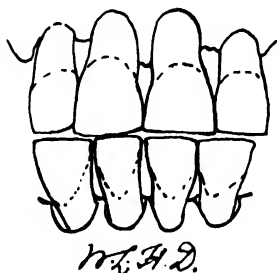
Fig. 106.   Fig. 107.

Fig. 106.   Incisor teeth of a Chimpanzee.   (young ♀.   W.L.H.D. priv. coll.)
Fig. 107.   Incisor teeth of an aboriginal native of Australia.   (Mus. Anat. Cant.)

ANTHROPOIDEA. Hominidae. Homo sapiens.

An aboriginal native of Australia (Fig. 107).   The upper median incisors are but slightly larger than the lateral incisors ; the crowns are extensive ; of the lower teeth, the lateral pair slightly exceed the median pair in bulk.

It has not been possible to describe in detail the features of the milk or transitory dentition in the several forms just considered.   It must suffice therefore to state that the milk teeth, while fewer in number than the permanent teeth, yet resemble these to some extent in form.   As is well known, the milk dentition of the Hominidae is completed (usually at the 20th month of life) by the acquisition of two incisors, a canine and two molar teeth on each side above and below, the formula (i, $\frac{2}{2}$; c, $\frac{1}{1}$; m, $\frac{2}{2}$) thus differing from that which obtains in adults (i, $\frac{2}{2}$; c, $\frac{1}{1}$; pm, $\frac{2}{2}$; m, $\frac{3}{3}$).   Of the several teeth, the incisors and canines resemble closely enough those by which they will be

succeeded; but with regard to the molar teeth, such is not the case; and the milk-molar teeth are succeeded by premolar teeth of the permanent set, not represented in the transitory dentition. These milk molars are moreover definitely molar in form, bearing four cusps, not two as in the replacing teeth. The advent of the permanent dentition is marked by the appearance of the first permanent molar tooth, which comes into position behind the last of the milk molar teeth.

Thus far the agreement between the Hominidae and Simiidae is complete, and in Fig. 32 (p. 46) the transition period in the skull of the adolescent Gorilla is represented; while Fig. 73 (p. 108) represents crania of Gorilla and Chimpanzee at an epoch in which the first molar tooth of the permanent series has established its position definitely.

From the subject of the replacement of teeth we must turn to that of variations[1] in the dental system, and these may be suitably set forth under the several headings of (a) Varieties in number, (b) Varieties in form, (c) Varieties in position, the permanent dentition being in all cases considered[2].

(A.) **Varieties in number.** These may be of two kinds, viz. (a) *where the number is increased*, (β) *where it is diminished*. It will be convenient to consider (a), the cases of increased numbers first. Adopting the same order as was taken in describing the characters of the teeth, the canine teeth must first be considered. Little is to be said here, as this region of the dental series seems little liable to variation. In the skull of a Gorilla at Hamburg the unusual anomaly of reduplication of the canine tooth is to be seen : there is no question of the retention of the milk-canine alongside the permanent tooth : but I am not aware that a parallel instance has been noted in the Hominidae.

Additions to the premolar series might be expected *à priori*, in view of the prevalence of three premolar teeth in the Cebidae, Hapalidae and Lemuroidea. As a matter of fact, an additional premolar tooth is of by no means uncommon occurrence[3], and such an anomaly may be regarded as of reversionary significance.

Not only may complete accessory or supernumerary teeth occur in the premolar region, but small dental masses too small and imperfect to be called

[1] The dental system in certain Cebidae, in Simiidae and Hominidae is liable to much variation, as many as 4 % of examples in Cebus and Ateles, and 8 % among the Simiidae presenting instances of supernumerary teeth (Bateson). For a detailed account, cf. Bateson, "Materials for the Study of Variation." In addition to this work that of Magitot, *Anomalies du système dentaire*, remains of classical value.

[2] Guttmann, quoted by Kükenthal (*Jahresberichte für Anatomie*, 1901), has recorded a case in which nearly all the milk teeth were retained in the presence of their successors in a youth aged 19.

[3] Cf. Magitot (*op. cit.*) for a very remarkable instance of supernumerary premolar teeth in the skull of a negro.

teeth[1], also appear with some frequency in Melanesian crania, especially between the last premolar and the first molar teeth in the maxilla. Of such cases,

Fig. 108.

Fig. 109.

Fig. 108. An accessory dental mass (x) in the maxilla of a native of New Britain. (Mus. Anat. Cant. W.L.H.D. del.)
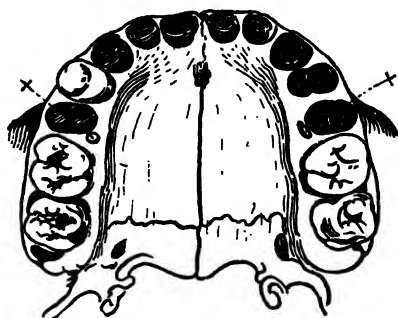
Fig. 109. Two accessory dental masses (x, x) in the maxilla of a native of New Britain. (Mus. Anat. Cant. W.L.H.D. del.)
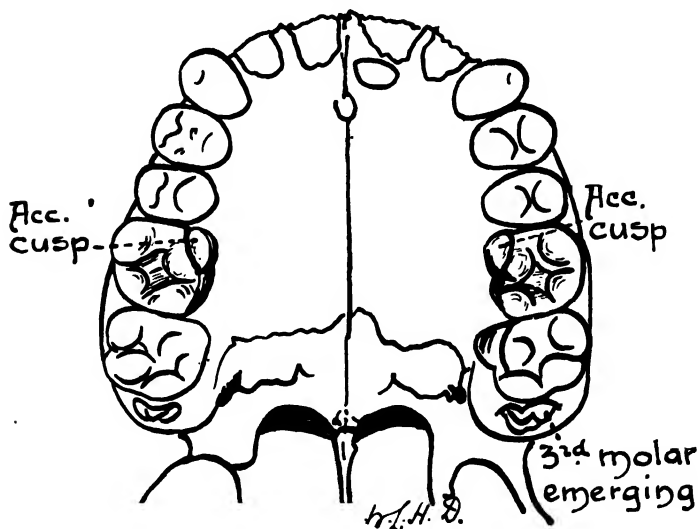
Fig. 110. Accessory cusps in the molar teeth of an Egyptian. (Mus. Anat. Cant. W.L.H.D. del.)

[1] Windle (*J.A.* and *P.* vol. xxi. p. 84) distinguishes very appropriately between "supernumerary" imperfect teeth and "supplemental" teeth of size commensurate with those adjacent to them.

examples are shewn in Figs. 108 and 109 : in the former instance a dental mass is seen on one side only (x. Fig. 108), while in the specimen represented in Fig. 109 the masses (x, x) are bilaterally symmetrical.   To Fig. 109 I have appended Fig. 110, which represents the upper teeth of a young Egyptian man.   If the figures be compared, it is hard to avoid the impression that the small masses in Fig. 109 may be derived from the molar teeth and that the projections from the cingulum (marked Acc. cusp in Fig. 110) represent the initial stages in the evolution of independent elements.   Otherwise if on the lingual side of the gums they may represent elements of the "post-permanent" dentition.   At present there seems no means of deciding between the several possibilities. It remains to remark that precisely similar masses are to be found in the crania of Simiidae, and that just as among the Hominidae the maximum of frequency obtains in the Oceanic-negro races, so in the Simiidae, the frequency is greatest in the Gorilla[1] (cf. Fig. 111).   It will be noted in this illustration that whereas one such dental mass is situated in the position already described, the second intervenes between the two upper premolar teeth.   Additions to the number of molar teeth may be by way of gemination, of which a good instance exists in an European skull (from Paestum) in the University Museum of Anatomy, while a
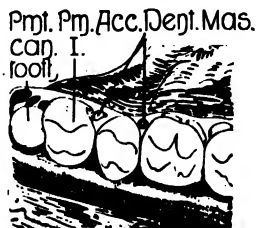
Fig. 111. Left upper teeth of a young Gorilla: accessory dental masses are situated between the first and second premolar teeth, and between the second premolar and the first molar tooth respectively.   (W.L.H.D. priv. coll.)
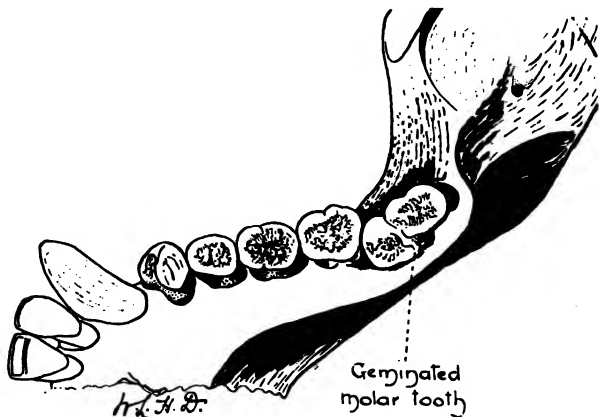
Fig. 112.   Gemination of the last molar tooth in the mandible of an Orang-utan (Selenka Coll., Munich).

[1] Cf. Duckworth and Fraser, *Proc. Camb. Phil. Soc.* 1900.

striking instance is shewn in the Fig. 112, which represents gemination in
the last molar tooth in the mandible of an adult Orang-utan.   The original
forms part of the Selenka Collection at Munich.

Completely-formed accessory molar teeth are not common in the
Hominidae, although the palate and alveolar arcade in many crania of
aboriginals of Australia seem to be spacious enough to accommodate them.
It is however in the cranium of such an aboriginal native that Sir William
Turner records the occurrence of no less than three accessory molar teeth,
and such anomalies are more frequent in the Melanesian and Australian
aborigines than in other Hominidae.   In the Simiidae, accessory molar teeth
are not uncommon, but the frequency of the occurrence is very variable :
in the Orang-utan (cf. x, Fig. 113) the frequency of occurrence is at a maxi-
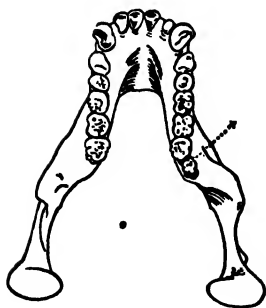
Fig. 113.
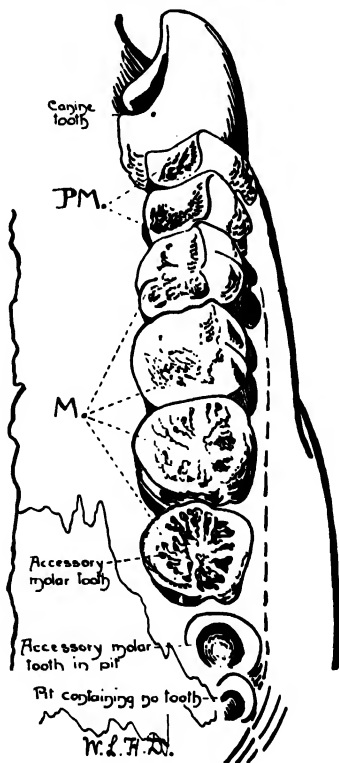
Fig. 114.

113.   Mandible of an Orang-utan (ad. ♂) with an accessory molar tooth on the
right side. (Hose Donation II.   Mus. Anat. Cant.)

Fig. 114.   Accessory teeth in the maxilla of an Orang-utan. (Selenka coll·
Munich.)

mum, particularly in the male sex, in which nearly fifty per cent. of cases
will be found to present this anomaly. This statement is based on the
examination of the very large collection (more than 200 crania) at Munich,
in the course of which the very remarkable example shewn in Fig. 114
was discovered. In this example four fully-formed molar teeth are seen :
behind the last of these is an aborted dental mass, and behind this a
depression which had probably contained yet another dental mass[1].

It remains to consider additions to the incisor series. Supernumerary
incisor teeth constitute a large proportion of the anomalies of the dental
system, and as in the preceding categories, care must be taken to distinguish
between veritable cases of accessory teeth,
and instances where the apparently super-
numerary tooth is merely a retained tooth
of the milk dentition. The distinction is
not always easy to draw, and an instance
of this is shewn in Fig. 115, where how-
ever the length of root exhibited by the
supernumerary tooth is evidence against
the case being one of retention (for the
milk teeth are not so deeply rooted as
those of the permanent series, and the
root is subject to a process of phagocytic
absorption which in fact leads to the ulti-
mate separation of the deciduous tooth
from its articulation). Supernumerary in-

Fig. 115. Mandible of an abori-
ginal Australian, with a super-
numerary incisor tooth. (Mus.
Anat. Cant.)

cisor teeth present another problem of some interest : viz., as to which of
the three incisor teeth so common in the Eutheria, has been suppressed so
as to leave the two incisors (on each side and in each pair) of the dentition
of the Primates. It must suffice to mention that the literature of the subject
shews that each of the three primitive incisor teeth has been claimed as the
defaulter.

As regards I_1 (the median incisor tooth), it may be remarked that the
wide interspace in the lemurine dentition between the upper median incisor
teeth is suggestive, and that a supernumerary incisor tooth is not infrequent
in this situation. Gadow adopts this view (and, I believe, Lydekker also) ;
Elliott Smith has recently recorded, while the present writer has observed,
instances of a supernumerary incisor tooth in the position indicated.

The view that I_2 is the missing tooth is supported by Turner, Albrecht,
and Wilson and is based largely upon considerations of the arrangement

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[1] Since examining the specimens at Munich I find that Selenka in describing
his Collection has commented upon the remarkable frequency of the occurrence of
additional molar teeth in male Orang-utans. Selenka states (" Rassen und Zahn-
wechsel des Orang-utan," *Sitz. der kais. preuss. Akad.*, Berlin, 1896) that the
anomaly is present in 20 per cent. of male crania.

of the incisor teeth in cases of persistence of the suture dividing the pre-maxilla and maxilla (hare-lip)[1].

Windle (*J. A. and P.*, vol. XXI., p. 84, *et seq.*) favours the view that I₃ has been suppressed; this view rests on the fact that the pre-canine space is a common locality for the occurrence of supernumerary teeth; while if it be granted that the characters of the teeth merge by insensible gradations into one another, the space in question is indicated as the probable site of the missing tooth which should provide the transition stage (at present lacking) between the definitely incisor and canine types of tooth-crown.

In regard to other anomalous conditions of the incisor teeth, records of gemination (cf. "gemination in the molar teeth," p. 139, and Fig. 112) of these teeth are noted by Windle (*J. A. and P.* vol. XXVIII., p. 374).

(β) *Variation by way of defects.* In the descriptive notes, the reduction in the number of cusps of the third upper molar tooth was frequently a subject of reference. The reduction may proceed to such a length that the tooth in question may be entirely suppressed. This is the commonest dental anomaly in the above category, and the frequency of its occurrence is at a maximum in the white races. Not only is this the case, but in the same races, there is a distinct tendency for the lateral incisors to disappear[2]. These phenomena are dependent very largely upon the progressive reduction of the maxillae, a process which has not yet been arrested. The normal dental formula thus tends to change, and to replacement by the formula presented by such anomalous examples, viz., i, $\frac{1}{1}$; c, $\frac{1}{1}$; pm, $\frac{3}{3}$; m, $\frac{2}{2}$[3]. These anomalies are more frequent in the maxilla than in the mandible, and it may be remarked in conclusion, that the loss of these teeth is not observed in the dentition of the Simiidae.

(B.) **Dental Variation in form.** The principal variations included in this category depend on the conformation of the various cusps in the pre-molar and molar series. Instances of gemination have been considered in the preceding section, and require only mention in the present connection. In certain of the Hominidae the incisor teeth are distinguished by their enormous size and curiously spatulate form. (Cf. Miklucho-Maclay: *Zeits. für Ethnologie*, Bd. VIII., see also Chapter XIV., *infra.*) This has been observed among men of Melanesian origin, and a similar condition may be seen in the teeth of an aboriginal native of Australia in the University Anatomical Museum.

[1] For expositions of this subject cf. Windle, *J. A. and P.*, vol. XXI., and Tomes, *Dental Anatomy.*

[2] Cf. *inter alia*, Rosenberg, *Morphol. Jahrbuch*, 1895.

[3] Even such a reduced dentition is surpassed by that of Daubentonia (Cheiromys, or Aye-Aye, a Lemuroid Primate-form).

(C.) **Variations in situation.** Displacement of teeth is rendered probable in cases in which the space available for their implantation is diminished without actual suppression of some of the teeth. This consideration provides an explanation of many cases of the occurrence of teeth in unusual situations, but is not altogether accountable for displacements observed in certain instances among the black races, in which the jaws are large and the space extensive.

The Anatomical Collection of Cambridge University includes examples of such occurrences in crania of aboriginal natives of Australia. In one such skull the canine teeth emerge on the facial surface of the maxilla, and their direction has been so altered that they lie in the horizontal rather than in the vertical plane. The same Collection contains the cranium of an ancient inhabitant of Peru, which presents a precisely similar condition of the same teeth. Again, the third molar tooth may emerge on the facial surface of the maxilla, immediately below the malar process : instances of this have been seen in an ancient skull from a cave in Jamaica : as also in the cranium of an aboriginal native of Australia (in the possession of Dr Haddon); while the same condition obtains in the skull of an Orang-utan in the Museum at Amsterdam.

The incisor teeth are subject to similar variations in position. Of these, perhaps the most striking are present in two crania from the Melanesian island of New Britain : in each of these specimens an incisor tooth has emerged, not on the alveolar margin of the maxilla, but on the lower margin of the apertura pyriformis nasi : in each case, however, the tooth is imperfectly formed.

The occurrence of teeth, more or less perfectly formed, in dermoid cysts and ovarian tumours, brings us into the domain of pathology, which must be regarded as beyond the scope of the present account.

From the foregoing descriptions it appears that the Hominidae, judged by their dentition, fall naturally into line with the Simiidae and indeed with the other Primates, the distinctive features of the human dentition being largely dependent on the characteristic reduction of the maxillary apparatus in this family (Hominidae).

There remain for consideration certain problems of general interest, viz. the evolution of the different types of tooth such as incisors, canines and the like, and also the origin of the characteristic phenomenon of the replacement of one set of teeth by another. We have seen[1] that the teeth are, in the Primates, naturally divisible into four classes (incisor, canine, premolar, and molar teeth) for the most part easily distinguishable, though at the same time there may be seen, even in a single jaw, such as that of an

[1] Chapter III.

Orang-utan (*v. ante* Figs. 92 and 93) evidence of a transition in type from one class to another. Such animals as present these variations in their normal tooth forms are described as heterodont, and are hereby distinguished from homodont animals, the latter possessing teeth of one pattern only; and usually it is found that homodont teeth are present in large numbers disposed along an elongated jaw.

Again, the animals in which replacement of a milk set of teeth by a permanent series has been observed, are referred to as diphyodont, in distinction from monophyodont animals, in which but one set of teeth is seen. The Primates (including Man), and indeed most of the higher mammals are heterodont and diphyodont.

In the endeavour to explain the origin of the different forms of teeth, such as the incisor, canine, and molar series, in other words in the attempt to render a clear account of the historical development of the heterodont dentition, it is tempting enough to refer all the various forms of teeth back to a simple ancestral parent-form; and the simplest form known is the conical[1] peg-like tooth found repeated in series with practically no variation (homodont)[2], throughout the length of the slender jaws of the toothed whales: moreover the reasonableness of this view seems enhanced by the fact that many reptiles (and a reptilian stage is postulated in the most widely-accepted view[3] as to the ancestry of the Mammalia, cf. the scheme in Chapter III. p. 30) possess such simple teeth, which are often described as haplodont[4]. Most reptiles are thus homodont, and it is from these, and not from

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[1] It appears that Rütimeyer first suggested that the conical tooth represents the ancestral form, cf. Forsyth-Major, *Proc. Zool. Soc.* 1893.

[2] Leche, *Bibliotheca zoologica*, 1895, demurs to the view that the homodont condition is the original mammalian one.

[3] The fact must not be ignored that certain observations suggest a direct origin of the Mammalia from the Amphibia, Reptilian ancestors being thus omitted from the direct line of descent.

[4] It is noteworthy that in many reptiles the teeth are ankylosed with the jaws, whereas in mammals the teeth are thecodont, that is are implanted in sockets, this being a form of articulation (not an ankylosis) known as Gomphosis. The difference between mammals and reptiles in this respect is not however absolute, for the Crocodilia are thecodont.

the rarer heterodont reptiles, that descent is traced by Cope (cf. *Factors of Evolution*, p. 331[1]).

Although, as a matter of detail, the theory which regarded the conical teeth of Odontoceti (toothed whales) as the parent form has been modified (a brief note on this subject is here appended)[2], nevertheless the prevalent view refers back the

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[1] Other morphologists, on the other hand, submit that the heterodont fossil reptiles known as Theriodontia, should be regarded as representative of the stock whence the Mammalia have sprung. The Theriodont reptiles present affinities with the Prototheria, and also with certain extinct Amphibia (cf. note 2 on this page; also, Woodward, *Vertebrate Palaeontology*, p. 247).

[2] The toothed whales (possessed of a homodont dentition) were at one time thought to lack a milk set of teeth, and were accordingly regarded as monophyodont; but Kükenthal's researches shew that they are really heterodont and also diphyodont, the first or "milk" set appearing as the normal teeth of these animals, while the second set of teeth is vestigial only. Moreover, Kükenthal (cf. *Denkschr. der med. naturwiss. Ges. in Jena*, Band 3, 1893, quoted by Schwalbe; *Anat. Anz.* 1894; also *Jenaische Zeitschr.*, Band xxviii. 1893, p. 76), found that even whalebone whales are provided with tooth-germs which early abort. These researches, together with those of Leche, indicate that the whales are the descendants of ancestors provided with more complicated teeth than those of the toothed-whales, and Kükenthal supposes that the numerous conical teeth of the latter result from the splitting up of several compound teeth. This suggestion is however by no means generally accepted, and in particular, Osborn and Gadow reject it. The Metatheria (Marsupials) appear to be monophyodont, but it has long been known that their most posterior premolar tooth is replaced: moreover Leche, Hill, and Wilson have discovered traces of other teeth which do not attain functional perfection. The Prototheria provide some evidence in the same direction, and in fact it is stated by Tims (*J. A. & P.* vol. xxxv. p. 321) that no mammal has yet been shewn to be absolutely monophyodont. Moreover, in addition to the two sets of teeth so characteristic of the Eutherian mammals, vestiges have been discovered of two other series, which may be described as constituting a "pre-milk" and a "post-permanent" set respectively. This discovery, which we owe to the work of Röse and Leche, has increased the complexity of the problem of deciding which sets of teeth are homologous in mammals of the various sections: and in particular, the identification of the ordinary set of teeth of Marsupials is still a matter of controversy. It is also to be remarked that according to the respective researches of Tims and Röse, the human foetus possesses unmistakeable vestiges of representatives of both pre-milk and post-permanent series, and it is a characteristic feature of the abortive tooth-germs that the so-called pre-lacteal germs should be developed on the labial side of those germs which proceed to become functionally active, while the post-permanent representatives are placed on the lingual side of the permanent teeth.

• In his exhaustive article in the *Bibliotheca zoologica* (Heft 17, 1895, Stuttgart), Leche remarks that in the four dentitions (which he distinguishes by Roman numerals I—IV), the several elements develop as follows:

various modifications of the teeth to a simple peg-like type, and the problem is resolved into the demonstration of the evolution of the complicated teeth found in modern mammals, from such

No. I. The teeth do not attain the stage of calcification, and are represented by vestigial buds only, situated upon the labial margin of the gum.

No. II. is regarded as the ordinary " milk " dentition.

No. III. is the ordinary permanent dentition.

No. IV. This series is usually represented by "buds" on the lingual side of No. III.: these elements may sometimes arrive at maturity and appear as definite teeth. Subsequently (in the same memoir) Leche discusses the subject of the reduction in the number of functional dentitions. He suggests that the reduction was necessitated by the circumstances under which the mammalia were evolved from pre-mammalian reptilian ancestors ; that however, only dentitions I. and II. have been inherited from such ancestors, III. and IV. being newly-evolved and peculiar to the mammalia. This position is not quite easy to grasp in view of the fact cited by Beddard (*Mammalia*, p. 53), that Leche has himself described in a reptile (Iguana), no less than four series of teeth which reach maturity, while a rudimentary (or vestigial) series, antecedent to these, never produces fully formed teeth.

But in the memoir quoted, Leche defends his position that new dentitions can arise, though he recognises the objections that have been adduced by Kowalevsky, Schmidt, and Schlosser. Finally, in a more recent memoir (*Bibliotheca Zoologica*, Heft 37, 1902) upon the dentition of the Insectivora, Leche brings forward further evidence in support of the foregoing view.

These discoveries of a number of dentitions, some of which are recognisable in the Hominidae, detracts to some extent from the value of Schwalbe's review of the subject as presented to the German Anatomical Society in 1893. Nevertheless that address still retains all its historical interest, and includes certain remarks which may here be briefly recapitulated. In the first place, Schwalbe points out the difficulty in determining criteria for the several series of teeth. He quotes Leche as pessimistically admitting that such criteria are not to be hoped for, though the same author clearly indicates that he regards each dentition as a tooth-generation. This question of the criteria is still a matter of discussion (*v. infra.* p. 150, footnote). Schwalbe emphasises the significance of the independence of the milk and the permanent series as regards their original positions, and this independence would seem to be extended to the other dentitions subsequently discovered. A large part of the memoir is devoted to a discussion as to whether the ancestral mammals had one or two dentitions, but this part of the question is of course no longer relevant, except as regards one point. For in drawing up a table of the several schemes which have been devised to shew the originator's views regarding the relations of the permanent to the milk-teeth, Schwalbe shews that he regards pre-molar and molar teeth as derived from conjoined elements from the two dentitions (*v. infra*, p. 152). Kükenthal has, I believe, shewn evidence of such a coalescence in a special instance, but otherwise the subject has not been finally decided.

The history of the evolution of the several series is thus to a large extent

primitive haplodont teeth, which were probably arranged in considerable numbers along the elongated jaw of the ancestral form.

Turning now to the dentition of the Primates, and especially to the higher members of the Order, it is intelligible that the process of reduction in the size of the jaws (a reduction which is contingent upon the gradual loss of the prehensile function, compensation for which is found in the increased activity of the fore-limbs), determined the reduction in the number of teeth, a process which still persists in the Hominidae.

As regards the form of the teeth: in the incisor and canine series the change from the original haplodont form has been comparatively slight, though whether the result has been determined by natural selection, or use-inheritance, would lead into a discussion upon which we cannot enter here.

But in the premolar and molar series the difficulties are greater: for the problem is to determine the origin of complex many-cusped teeth with multiple roots, from conical teeth with single roots.

The explanations which have been offered may be grouped under three headings: viz. the hypotheses of Trituberculy, of the Polybunodont origin of the teeth, and the hypothesis advanced by Marett Tims, with which the Concrescence theory will be considered.

It must be at once stated that no one hypothesis will cover all the cases, and hence it is necessary to enter into brief notices of each.

The tritubercular hypothesis is inseparably connected with the names of Cope and of Osborn[1], two American palaeontologists,

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obscure: the general significance of the replacement of one dentition by another must evidently be found in the advantage therefore conferred on the animal, which is thus able to bring series after series into use, as the preceding set is lost or worn away. And whether two, or all four of the dentitions recognisable in the Hominidae, are inherited from ancestors in the reptilian phase or no, the general conclusion must be that the multiple dentition has been inherited from polyphyodont ancestors, and has subsequently been modified in accordance with the special needs of this family of the Primates.

[1] Cf. Cope, *Primary Factors in Evolution*; Osborn, *American Naturalist*, 1888, p. 1074; *ibid.* 1893 and 1897.

and it is interesting to note that the theory is largely a generalization from the experience of extended investigations of the characters of fossil teeth. It may be stated in the following way.

Starting from the simple haplodont tooth, it is pointed out that the arrangement of these teeth is such that the members of the upper and lower arcades alternate: the result of this alternation is that each tooth will be touched by two others when in action, and this contact will be at the anterior and at the posterior surfaces.

To the mechanical irritation of such contact, an appeal is made for an explanation of the two subsidiary processes or cusps found in the next successional stage, in which the primitive cone is supplemented by a small anterior cone, and a similar posterior cone, as shewn in Fig. 116, where the central circle represents the primitive cone of an upper tooth, the smaller circle or cone (P'), being anterior, and that marked (m) being posterior.
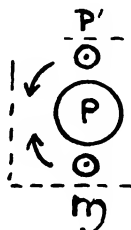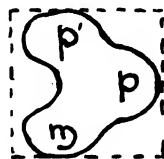
Fig. 116.   Fig. 117.

Figs. 116, 117.   Diagrams of the primitive molar cusps, shewing the change in position which gives rise to the trituber-cular type of molar tooth.

From this stage, a passage is effected to that represented in Fig. 117 in which the subsidiary cones have been rotated with respect to the primary cone. Circumduction takes place in the direction of the arrows shewn in Fig. 116, and again the mechanical action of the jaws in mastication is appealed to as an active cause of the process. Moreover the direction of circumduction differs in the upper and lower jaw, the tooth in the upper jaw being left with the secondary cones as shewn in Fig. 117, viz. on its external surface, whereas in the lower teeth, these cones would be found on the internal side[1].

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[1] This process has been very ingeniously described by Ryder (*Proc. Philad. Acad.* 1878), as depending on the lateral movement of the mandible across the maxilla, whereby the small cusps will be swept outwards in the maxilla, and inwards in the mandible.

The primitive cone is designated the protocone (P, Figs. 116 and 117), the anterior subsidiary cone the paracone (P', Figs. 116 and 117), and the posterior the metacone: a primitive trigon or triangle is thus formed, and provides the tritubercular pattern which has given its name to the hypothesis.

The American palaeontologists (Cope, Osborn, and Marsh) are able to point to a great number of extinct Eutherian mammals in which this stage has been reached, and among recent Eutheria (for example, Gymnura), and Primates in particular, it is clearly recognisable (whatever the path by which it has been arrived at), as in the molars of the Lemurs, and indeed in certain cases in the molars of the Hominidae.

From this point however, the lines of evolution appear to diverge, and to differ in the upper and lower teeth. Essentially, the changes consist in the addition of further cusps, which are regarded as derived from the cingulum, an elevated zone or band which encircles the crown of the tooth, usually at the lowest part, where the crown gives place to the root. (The cingulum is already present in the haplodont conical tooth.) Cope and Osborn have traced the development of the (subsequently) strongly-contrasted Ungulate and Carnivorous types of molar tooth, from this common stage, but it would not be appropriate to enter here upon this subject. Coming now to the Primates, and considering the lower molar teeth (cf. Figs. 116, *et seq.*) we note the tendency to the production of four or even five cusps. The cusps thus added are formed at the posterior end of the tooth, on a process of the cingulum which is known as the talon. Upon this talon a fourth cusp is developed; in position it is postero-external and is thus shewn in Figs. 119 and 121 (in Fig. 121, it is indicated by PE); and yet further cusps may be added, the fifth usually assuming an intermediate position marked by y in Fig. 119 and *Acc.* in Fig. 121. This arrangement of cusps is, as we have seen, found to obtain throughout the lower molars of Anthropoidea including the Hominidae.

In the upper molar series, the tritubercular arrangement remains typical in the Lemuroidea, while in the Anthropoidea (cf. Figs. 85—99 incl.) a four-cusped tooth is the rule. Moreover the protocone and the metacone (cf. Fig. 118 AI and PE) are

connected by an oblique ridge in the Simiidae and the Hominidae though (and this is important) not in the Cercopithecidae, nor in most of the Cebidae, though there are exceptions among the latter. The fourth cusp is called the hypocone, and Osborn (*Am. Nat.* 1897)
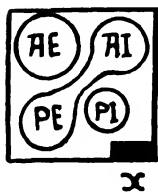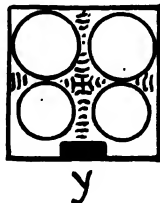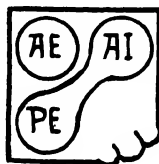
Fig. 118.   Fig. 119.   Fig. 120.   Fig. 121.
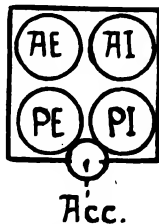
Fig. 118.   Diagram of the cusps in an upper molar tooth : the indications are *AE*, antero-external, *AI*, antero-internal, *PE*, postero-external, *PI*, postero-internal cusp : "*x*" represents the position in which additional cusps usually appear, as seen in Fig. 120, which represents an upper molar tooth.   (Cf. also Fig. 96.)

Fig. 119.   Diagram of the cusps in a lower molar tooth : additional cusps tend to appear at "*y*" as shewn in Fig. 121, which also represents a lower molar tooth with an accessory cusp.   For the significance of the letters, cf. Fig. 118.

regards it as a derivative of the cingulum.   This hypocone is indicated by *PI* in Fig. 118, and the region *x* (Fig. 118) may produce other subsidiary cones.   Where the tooth is in a retrogressive condition, as in the third upper molars of Anthropopithecus, Pithecanthropus (cf. Chapter XVII.) and Homo, several degenerate cusps may replace the hypocone, and the appearances seen in Figs. 96 and 120 represent such a result.

It is convenient to note here that the four-cusped arrangement seen in the upper molars of the higher Primates, is regarded by Cope as representing a comparatively early stage in the history of the complicated molar teeth of the Ungulata.   In this respect therefore the Primates are to be regarded as comparatively primitive.

Leaving the molars for the moment, it must be admitted that the exact history of the bicuspid premolars is not clearly explained by Cope in his latest work (*The Primary factors of Organic Evolution*, 1896).   It is there stated that according to Scott and Allen, the internal premolar cusps are to be derived from the

cingulum, and to this proposition Cope gives a somewhat hesitating assent[1].

The premolars have been largely reduced in number in the Primates, and especially in the Catarrhinae[2]; it is noteworthy that Osborn regards the primitive mammalian dental formula as i, 4; c, 1; pm, 4; m, 8 (cf. Oldfield Thomas' formula: viz. i, 4; c, 1; pm, 4; m, 3), shewing hereby that he regards the reduction at the molar end of the series as very great.

Thus far the application of the tritubercular theory seems perfectly correct, and the exposition of the subject would be greatly simplified were it possible to place implicit reliance upon this theory. But while expressing the conviction that this view will be ultimately accepted in a modified form as applicable to the Primates, being largely accountable for the facts observed, it is impossible to overlook certain grave objections to its unreserved acceptance. In the first place, it seems undeniable that embryologically the cusp first developed is not the protocone, as should be the case in accordance with the hypothesis (cf. Taeker, quoted by Osborn *Am. Nat.*, 1893; Woodward, quoted by Tims *J. A. P.* xxxvii. p. 137; Tims, *op. cit.* p. 137; Heischmann, quoted by Röse, *Anat. Anz.* Band vii. p. 394; and Röse, *ibid.*), nor does there seem to be any embryological evidence of the circumduction (often spoken of as the rotation) of the secondary cusps.

It might thus seem that the objections are directed from the side of embryology only, but Tims (*op. cit.* p. 138) claims that the evidence of palaeontology is by no means flawless.

Some of the earlier opponents of Cope's theory are ranged on the side of Forsyth-Major, who (*Proc. Zool. Soc.* 1893), for Rodents,

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[1] The point is of importance, because there is a difficulty in defining the exact difference between a molar and a premolar tooth. The older writers seem to have believed that whereas the premolars are preceded by milk teeth, the true molar teeth are not so preceded. Difficulties in the applicability of this criterion having arisen, a difference in developmental history was somewhat eagerly seized upon as an alternative test, but this in turn seems to be a controvertible point, in view of the researches of Marett Tims (cf. *J. A. P.* xxxvii. p. 146).

[2] Brunsmann (quoted by Kükenthal, *Jahr. der Anatomie*, 1902) seems to have postulated a stage in human ancestry in which the dental formula was

$$i, \tfrac{3}{3}; c, \tfrac{1}{1}; pm, \tfrac{3}{3}; m, \tfrac{4}{4},$$

and has been engaged with Adloff (cf. Kükenthal, *op. cit.*) in controversy on this subject.

proposed an alternative theory, known commonly as that of Multituberculism or Polybunodontism. Forsyth-Major believed that the most primitive known mammals are provided with teeth which, far from being simple cones, are furnished with many small cusps. Such is the form of the only teeth found among the Prototheria, and not only in the recent, but in the fossil examples[1], which are by some regarded as the most primitive of known fossil mammalia[2].

It was thus suggested that the several rodent tooth-forms are to be regarded as derivatives by fission, to a greater or lesser extent, of a primitive polybunodont mass.

But the difficulties in the way of an application of this theory to the Primates would appear very great[3].

Another view is that of Tims (*op. cit. passim*), who was impressed with the fact that the cingulum is capable of throwing up offshoots in the form of cusps. This fact is duly recognised by the exponents of the tritubercular theory both as regards the pre-molar, and to some extent as regards the molar teeth. Tims proposes to adopt this explanation as regards the pre-molar teeth, while as regards the molar teeth, and this is an important point, he suggests the concrescence of primarily distinct elements placed originally in an antero-posterior sequence[4]. Antero-posterior concrescence is the keystone of Tims' theory as regards the molar teeth, and it must be admitted as unfortunate that the evidence of concrescence is not yet convincing, except in Sphenodon (a reptile), and Ceratodus (a Dipnoan fish)[5].

Concrescence indeed has been assigned, as a name, to a definite theory, which would seem (cf. Marett Tims, *J. A. P.*, vol. XXXVII. p. 134), to have been first advanced by Gervais. Its chief advocates in later years have been Röse and Kükenthal, against whom we

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[1] Osborn deals with this theory in an essay in the *American Naturalist*, 1897, pp. 993 *et seq.*

[2] Woodward, *Vertebrate Palaeontology*, p. 247.

[3] Tims (*op. cit.* p. 139) confirms the application of the theory to the Rodentia.

[4] In the Primates and most Eutheria concrescence of pairs of such elements is suggested, while in the Elephants a greater number of elements would appear to have been fused together.

[5] But not in Protopterus, another Dipnoan fish (cf. Röse. *Anat. Anz.* VII. p. 399).

may set Leche (*Bibl. Zool. Heft*, 17, pp. 154, 155). The theory postulates the possibility of primitive conical dental elements fusing to form complex teeth: and the elements which thus fuse may belong to one and the same, or to different dentitions.

Röse (*Anat. Anz.* VII. p. 395) declares himself an advocate of the Concrescence-theory as accountable for the origin both of pre-molar and molar teeth, and has represented his views in an elaborate diagram. It may be noted in conclusion of this brief notice, that Röse postulates the original presence of from 46—52 single conical teeth, which by fusion have constituted the dentition actually found in the Hominidae. Such a number of conical teeth is submitted to be not by any means unusual in the dentition of reptiles.

The foregoing notes contain an attempt to set forth in the most concise manner the several views which have been taken, and the hypotheses which have been advanced in explanation, of what is undoubtedly a difficult problem, and one upon which much light remains to be shed.

The tritubercular theory has been discussed at greater length than the other views, partly because of its special applicability to the Hominidae, and also because of the very important inferences based upon this by Cope and set forth by him in the *American Naturalist* (1893), and again, at a later date, in the *Primary Factors of Organic Evolution* (1896).

The molar teeth are the special object of study, and Cope and Topinard agree in declaring that the Hominidae, and especially the more highly civilised among recent Hominidae, are tending toward the reversionary condition of trituberculy in the upper molars, the hypocone (cf. Fig. 118, "*PI*") tending to disappear. Topinard (*L'Anthropologie*, 1892) gives some striking statistics from a research on several hundred crania, and has drawn up comparative tables illustrative of the tendency in the several human races (cf. also Tomes' *Dental Anatomy*, 1898)[1].

This tendency to trituberculy (which is undoubtedly demonstrable) is considered by Cope[2] justification for the inference that

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[1] Both these writers appear to ignore the earlier work of Zuckerkandl and Röse (cf. Chapter XIV.).

[2] Haeckel and Klaatsch seem to be in agreement with Cope upon the general accuracy of this account.

the Hominidae and Simiidae have descended directly from Lemurine ancestors, to the exclusion of a "Cercopithecus stage" in the genealogical history of these two families.   Extinct lemurs are appealed to, especially the small animal known as Anaptomorphus (cf. Chapter XVII.), whose nearest living relative is the very primitive Tarsier (cf. Chapter II.); also the various representatives of the Genus Adapis (cf. Chapter XVII.) which command a special interest in view of the features of their lower incisor teeth[1].

From these forms Cope considers that a transition can be reasonably claimed as demonstrable, to the extinct Eutherian groups known respectively as Condylarthra (ancestral ungulate forms), and Creodonta (ancestral carnivorous forms), while from the latter the passage to very primitive or generalised marsupials of a polyprotodont type (cf. Chapter II. p. 20; Chapter III. p. 28) is readily intelligible[2].

The ancestry of the Hominidae is thus retraceable to a marsupial stage, and in point of time to the Jurassic period, beyond which no definitely mammalian remains are forthcoming[3].

If, now, the question as to the cause of the differentiation of distinct dental types in the several regions of the jaws be investigated, the exponents of the tritubercular theory will be found to appeal as in other instances to functional adaptation as the prominent factor at work (cf. Cope, *Primary Factors*, pp. 319 *et seq.*).   Certainly the mechanical conditions will differ widely in different parts of the jaw; it is suggested that whereas the primary need was originally prehension, and that the crocodilian

[1] As was mentioned in the descriptive notes on the teeth of the Lemuroidea, the true Lemurs are distinguished by the very peculiar procumbent position and the extraordinarily styloid shape of their lower incisor and canine teeth.   The possession of this character would be an obstacle to the acceptance of the view which should postulate the appearance of such Lemurine forms in the ancestry of the Hominidae.   The character has not been lately acquired, for the giant extinct Lemurs possess it (cf. Chapter XVII.), but Cope (*Am. Nat.* 1893) is able to shew that several of the extinct Adapidae possessed a more generalised conformation in regard to the teeth in question.   The typical Lemurine conformation is regarded as the result of adaptive specialisation.

[2] Forsyth-Major (*Proc. Zool. Soc.* 1893), and Marett Tims strenuously oppose this view.

[3] Cf. Cope, *Primary Factors &c.*, p. 141.   Representatives of the monotremes (Prototheria) have been found in the Lower Eocene, but not so far in strata of such early date as the Jurassic.

or cetacean types of dentition provide good examples of this; it is urged that with the acquisition and development of the habit of masticating food (whether like a primitive insectivore in crushing the scaly coats of its prey, or a primitive ungulate in reducing vegetable matter to pulp, or again in the habit of shearing flesh from bone as shewn by Carnivora), specialisation and adaptation were associated in that section of the dental series at which power could be most advantageously applied; and it is submitted that the comparative simplicity of the anterior teeth is contingent upon the retention of the prehensile function by this portion of the dental arcade.

So finally, when the dentition of the Hominidae is considered, the interpretation thus advanced is found to apply to these, equally with other Eutherian mammals, with the special qualifications introduced by the factor to which reference has been so often made, viz. the peculiar degree of reduction of the maxillary apparatus and the concomitant limitation of its functions.

SECTION B.

EMBRYOLOGY.

CHAPTER VII.

THE EVIDENCE OF HUMAN EMBRYOLOGY.

General considerations. The foregoing chapters have had as their aim the demonstration of the fact that Man is associated in a natural zoological classification with certain other mammals in the Order Primates. It is now suitable to take up the second subject proposed for consideration in these notes, and to endeavour to ascertain something of Man's ancestral history, that is, of the path of evolution traced by Man. The means available for carrying out this enquiry are at the present day threefold: (1) embryology, (2) the comparative morphology of the various human races, and (3) palaeontology. The importance of the first-mentioned study, viz. embryology, depends upon the well-known generalization made by Kowalewsky following v. Baer and Meckel, to the effect that the individual organism recapitulates in its own developmental history the several stages through which its ancestors passed in their evolution. The second study, viz. the comparative morphology of human races may be expected to reveal the most recent stages only, and to indicate the steps by which the more highly evolved of human beings have arisen through the modification of their lowlier and more archaic brethren. The last-mentioned science supplies information as regards extinct forms of life, some of which may be regarded as at any rate representative of, if not themselves actually human ancestors.

It is thus that the study of human embryology now demands attention. It follows from the principle of recapitulation which is set forth above, that the human embryo should provide material for the reconstruction of the history of the human race, that the developing human being should pass through every phase of the evolutionary path trodden by the human family. But embryological study soon shews that this history is at best epitomised or abstracted, that certain episodes are glossed over, certain phases either so abbreviated as to be hardly perceptible, or actually omitted.

The evidence of embryology must not therefore be expected to prove exhaustive, and with this proviso, the application of the recapitulation theory to the special case of Man may be attempted. Concerned as we are with the later stages of human evolution, the later stages of human embryology may be expected to provide information of the kind required. It may be at once stated that studied from the general zoological standpoint, the embryology of Man indicates his descent from an uni-cellular form of life through invertebrate phases to a vertebrate series of stages; in certain of the latter, definite resemblances to a fish-form can be traced; these are followed by other phases, in which are seen features transitory in the human foetus but permanent in the lower mammals, and hence indicative that the path of human evolution has passed through stages corresponding to these. Following up this train of evidence, it seems reasonable to suppose that in the progress of human development, periods occur at which the condition of the foetus reproduces that of the later or less-removed of human ancestors; and in fact, the con-clusion is arrived at, that on the hypothesis that evolution is the method of origin of animal forms, there should be demonstrable in the human foetus characters distinctive of non-human ancestors rather than of Man himself. In other words, the human foetus should present transitorily the permanent morphological features of lower members of the Primates, and this is the subject now proposed for consideration[1].

With these preliminaries, we may turn to a matter of practical study and approach the subject in the form of an examination into the morphology of the developing human embryo. It will be convenient to retrace the steps of human development, and to deal with the human foetus, primarily at the time of birth[1], secondarily at about half-way through its foetal life, and to enquire what are its morphological characters, and whether these can be justifiably regarded as more ape-like than those of the human adult.

The anatomy of the foetus may be most profitably studied under the following headings :

　　　　　(*a*) external features,

　　　　　(*b*) topographical anatomy,

　　　　　(*c*) systematic anatomy,

and brief summaries of the results will be appended to each section.

(*a*) **External features.** (i) In reviewing the principal distinguishing external characters of the human infant at birth the proportionately large size of the head at once claims notice. The eyes appear more widely separated than in the adult (Blind[2]). The nose of the infant is flat and wide, presenting characters which are retained to maturity by the lowlier human races. Owing to the relatively diminutive size of the mandible and the lack of development of the maxilla, the face is broad rather than long. This appearance is enhanced by the existence of special encapsulated fatty masses lying beneath the risorius muscle (and superficial to the buccinator muscles) on each side. They are termed the " sucking pads." The trunk is relatively stout, its parietes are straight in direction and nearly parallel, a condition retained in the negro races. The umbilicus is situated low down

is possible that the phases in question are hurried over very rapidly, or are even omitted from the story of human embryology as being comparatively unimportant events in the history of the human family, events far less impressive at any rate than the substitution of lungs for gills as the organs of respiration ; or again, it may be that our observations are not at present sufficiently exact, and that though the ape-like features are present, yet we cannot recognise them.

[1] In the following pages the anatomy of the new-born infant is not distinguished from that of the foetus during the last month of pregnancy, except as regards the respiratory and circulatory systems.

[2] Hugo Blind, *Nasenbildung bei Neu-geborenen*, Munich.

on the abdominal surface, and the incomplete development of the pelvis is shewn by the lack of breadth at the hips, and by the prominence of the abdomen, which at this stage contains organs, such as the bladder, which are subsequently accommodated rather in the pelvic than the abdominal cavity.   While in the foregoing respects, the infant differs from the adult, yet the permanent conformation has been nearly attained in the hand, which is broad, and provided with cutaneous grooves expressive of the actions respectively of the flexor, adductor, and opponens groups of muscles[1].   The proportions of the foot too are similar to those of the adult, but the plantar arch still awaits development.   The hallux is parallel to the other toes, and there are cutaneous grooves on the plantar surfaces, which are very characteristically inverted.   The mobility of the human toes at this epoch constitutes a merely superficial resemblance to apes, as the difference in the anatomical conformation of the foot of the human infant and of the apes precludes absolute similarity.   At most, as Fowes has pointed out, the so-called grasping action of the infant's hallux is a movement of adduction, unaccompanied by opposition. The upper limb is almost as long as the lower limb, and herein lies a simian feature which will be further dealt with in Chapter XIII.

The downy covering of lanugo has been almost completely lost, and an abundant cutaneous (sebaceous) secretion (the so-called vernix caseosa) is very remarkable.

The external female genitalia appear to be incompletely developed as compared with adult examples, the labia majora being relatively smaller, and exposing the labia minora (Ballantyne).   In both sexes the gluteal fold in the infant is obscured, owing to the lack of development of the underlying and adjacent muscles, and the anal aperture is much more prominent than in later stages.   The last-mentioned character must be claimed as simian.

(ii)   When we pass from the study of the foetus at the ninth month to that of the foetus at the fourth or fifth month (Fig. 122) (measuring 150 to 200 mm. in length), we notice that the eyelids are closed, that the nose is flat, that the chin lacks prominence, and

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[1] Cf. Hepburn, *J. A. & P.* XXVII. p. 112 ; XXIX. p. 31 : also Chapter V, p. 100.
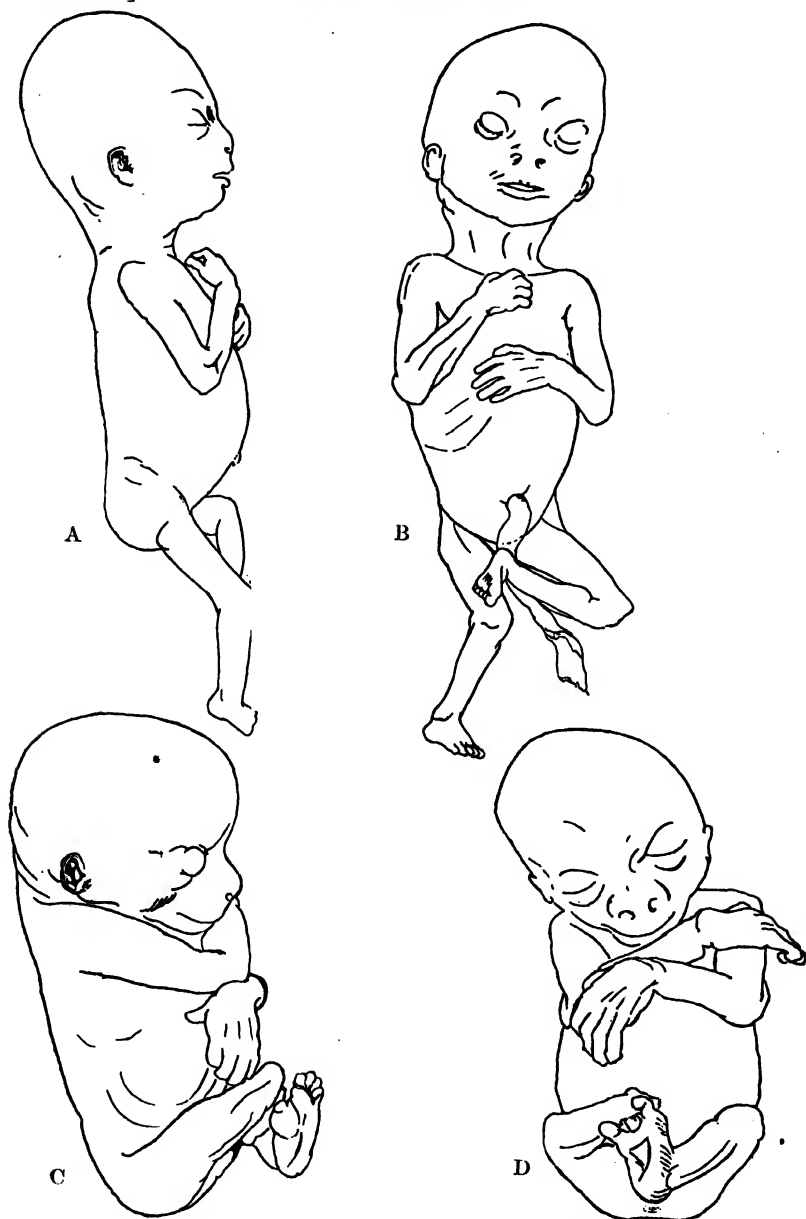
Fig. 122.   A and B, outline drawings of a human foetus (said to be 4½ months old), from photographs, and of the actual size of the specimen.

C and D, similar drawings (of actual size) of foetus of gorilla.

that the head is unduly large. The general appearance of the foetus is almost emaciated as compared with the ninth-month foetus, owing to subcutaneous fat being scanty in amount in the
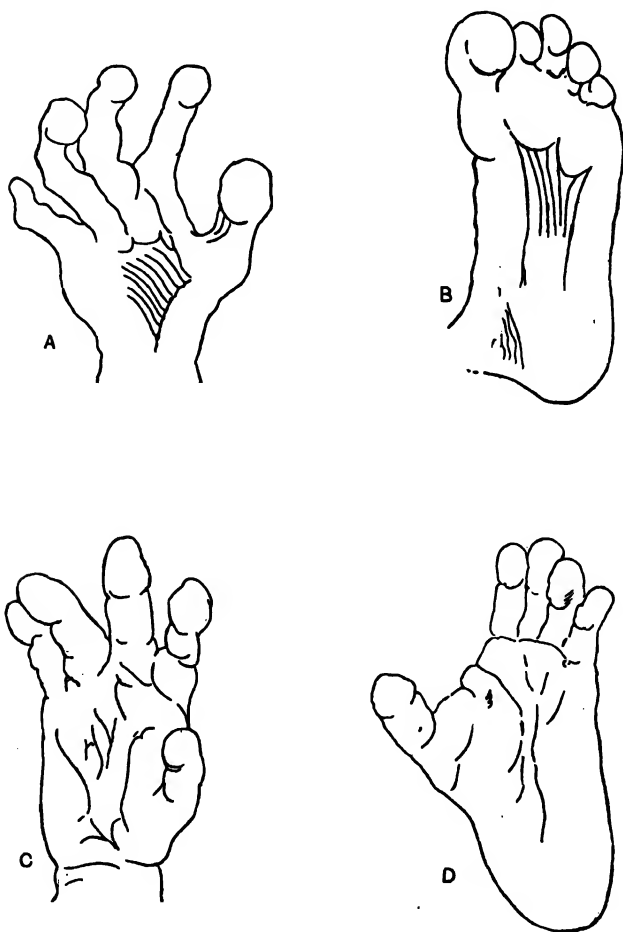
Fig. 123. A and B, outline drawings from photographs of palmar and plantar surfaces of the extremities of a human foetus (No. 29 of the Lee Collection), said to be 4 months old.

C and D, corresponding palmar (C) and plantar (D) surfaces of the extremities of a foetal gorilla (Mus. Zool. Cant.).

All these are enlarged from photographs of the original parts. Thus C, with an original length of 13 mm., has been enlarged 3½ times, and D (original length 15 mm.) has been enlarged 3⅔ times. A and B were originally of smaller size than C and D respectively, but have been enlarged to similar dimensions for the sake of comparison.

former.   Partly owing to a similar reason, the neck looks longer and thinner at the fourth to the fifth month than at the later epoch.   The sucking pad has not developed sufficiently to give the characteristic effect to the countenance.   The umbilicus is situated very low upon the abdominal surface, and the breadth at the hips is small.   The hand and foot (Fig. 123) at the end of the fourth month appear to have nearly attained the proportions which they exhibit at birth : the plantar surfaces of the feet seem less inverted than in the later stages, and the distinction from the hand and foot of the Simiidae (whether adult or foetal) is perfectly easy and clear.   It is uncertain whether the cutaneous grooves, even at the third month, may not be due to shrinkage caused by the preservative fluids in which the foetus has been immersed. The lanugo (a down-like covering of fine hair) at the end of the fourth month is widespread.   The external genitalia of the two sexes are perfectly distinct, and do not occupy positions similar to those which they possess in the Simiidae, so that there is no suggestion at this stage of a closer resemblance to those animals.

The external ear is still imperfect, owing to the union of the several tubercles to which it owes its origin being still incomplete. The proportions of the limbs distinctly suggest simian relations, for the upper limb is relatively to the lower much longer (varying from 98·6 % to 120 %) than in the adult (69 %)[1].

Conclusions from the external conformation of the foetus at 9 months, and at 4—5 months respectively.

In both stages certain simian characters are recognisable, but it is remarkable that the younger stage does not shew these in any greater frequency or degree than the later stage.   The inference is that though human evolution through a simian stage is suggested, many and essential details are lacking, or at least are unprovided by the external features.

(*b*)   **Topographical anatomy.**   (i) The topographical anatomy of the foetus at the ninth month has been studied by Merkel, Chievitz, Cunningham, and Ballantyne[2]; the following account is

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[1] Cf. Chapter XIII.

[2] *Manual of Antenatal Pathology and Hygiene*, 1902.   (Camb. Univ. Lib. 310b. 90. 2.)

largely based upon the work of the last-mentioned authority. Considering the head first in order, the average dimensions of the cranium (when it has recovered from the distortion attendant upon birth), are stated to be about 130 mm. in maximum length, 100 mm. in maximum (biparietal) breadth, and 87 mm. in the temporal region, the latter diameter being unaffected by pressure during parturition, which may result in very considerable, though as a rule temporary, modification of the other diameters. The circumference of the head is from 340 to 350 mm. (Gönner[1]), (or rather less; 325, W.L.H.D.).

As regards cerebro-cranial topography, it would appear from the researches of Cunningham that the angle of the Sylvian fissure is more acute (62°) in the human infant than in the adult (67°), and that the posterior limb of the fissure is placed above the line of the squamous suture, which however it has been approaching from the time of its earliest formation. The change is due, not only to the growth of the squamous portion of the temporal bone, but also to the enlargement of both the fronto-parietal and the temporal parts of the cerebral hemisphere, an enlargement in which the growth of the fronto-parietal element predominates, so that the posterior limb of the Sylvian fissure moves downwards laterally at the expense of the temporal lobe. The upper end of the central sulcus is nearer to the coronal suture than in the adult, but with reference to the cerebral hemisphere, i.e. its distance from either pole of the hemisphere, the upper end of this sulcus is remarkably constant in position, from the time of its appearance. The variation in relation to the coronal suture is therefore expressive of the variable extent to which the parietal and frontal bones respectively cover this region of the brain. Though very nearly complete, the opercula fail in most cases to entirely overlap the central lobe (insula).

The cerebellum is fully overlapped by the occipital poles of the hemispheres. The spinal cord ends at the level of the first or second lumbar vertebra (Ballantyne).

In considering the anatomy of the neck and trunk, it is to be remembered that the normal position of the infant is one in which

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[1] Gönner, *Zeitschr. für Geburtshilfe und Gynäkologie.* Bd xxxiii. p. i.

the spine is flexed, so that when this attitude is exchanged for
that of extension, in which comparisons with the adult form are

Vertebrae.

Levels of the Viscera, etc., in a Foetus at the 9th month.		*Levels of the Viscera, etc., in a Foetus of 4—5 months.*
Epiglottis.	**C I**	Epiglottis.
Hyoid bone.	**• II**	Hyoid.
	• III	Cricoid.
	• IV	Isthmus of Thyroid.
Cricoid.	**• V**	
Isthmus of Thyroid.	**• VI**	
Oesophagus inclines to left.		
Manubrium.	**• VII**	
Coracoid		
Acromion.	**Th I**	Upper limit of Sternum and Thymus.
Upper limit Aortic arch.	**• II**	Upper limit of Aortic arch.
Bifurcation of Trachea. Thymus.		Thymus and Pre- and Meso-sternum.
	• III	Aorta reaches spine.
Aorta reaches spine.	**• IV**	Bifurcation of Trachea. {Manubrium
Heart base.		Lower limit {and Thymus.
Ensiform cartilage.	**• V**	
	• VI	
	• VII	Heart apex; upper limit of vault of Diaphragm.
Spleen.	**• VIII**	Ensiform cartilage.
Central tendon of Diaphragm. Heart apex.		
Spleen. Oesophagus pierces Diaphragm.	**• IX**	Oesophagus pierces Diaphragm.
Spleen.	**• X**	
	• XI	
	• XII	Pylorus.
Pylorus.	**L I**	
Pancreas. Termination of Spinal Cord.	**• II**	Duodenum crosses Spine.
Duodenum crosses Spine.		Termination of Spinal Cord.
	• III	Umbilicus.
Aorta divides into Iliac Arteries.		Aorta divides into Iliac Arteries.
	• IV	
	• V	
	S I	Top of Bladder. Fundus of Uterus
	• II	
	• III	Top of Symphysis pubis.
Lowest limit of Peritoneum on Rectum.	**• IV**	
	• V	
	C I	
	• II	
	• III	
	• IV	

Fig. 124.   Diagrammatic representation of the topographical relations of important
organs to the vertebrae in the foetus at two different epochs.

more profitably made, the new condition is (to say the least of it) anomalous.   Bearing this in mind, however, it may be noted that in the neck the hyoid bone and the larynx are situated higher up than in the adult, and are thus in a state of transition.   Reference to the diagram (Fig. 124) shews the general position of these structures with reference to the cervical vertebrae.

Like the cervical organs the thorax is situated nearer the head in the infant than in the adult.   The positions of the manubrium (Th. I.) and of the central diaphragmatic tendon (disc between Th. VIII. and Th. IX.) shew this.   The high position of the latter is perhaps associated with the lack of development of spinal curves, but more directly with the conjoined conditions of uninflated lungs and relatively large liver.   The sulcus pulmonalis on either side of the spine is shallower than in later life.

In accordance with the position of the thorax the pectoral limb girdle occupies a high position, the coracoid being above the level of the first rib, and the clavicle thus being higher at its outer than its inner end.   The whole scapula is about one rib higher than in adults, and in consequence of the peculiar shape of the infantile thorax is placed more nearly in the sagittal plane than in the adult.   (Fig. 125.)   The sternum is very obliquely placed, the
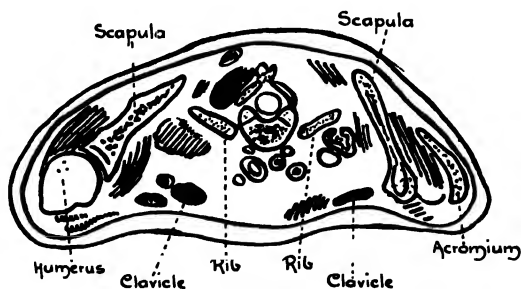
Fig. 125.   Section through the upper thoracic region in a human infant (at birth): the scapulae are placed laterally, and have not acquired the posterior position which they occupy in the adult.

lower end projecting anteriorly far beyond the upper.   The ribs are rather more horizontal than in the adult.   The heart (in the foetus) is placed more transversely and horizontally in the thorax and at a higher level as regards the spine.   Its limits will be seen indicated in the diagram.   (Chievitz notes that in the flexed

intra-uterine position these limits are quite different; the disc between D. IV. and D. V. being replaced by D. III., and the disc between D. VIII. and D. IX. being replaced by D. VIII.). Anteriorly, a considerable area of the heart uncovered by the lungs is overlain by the thymus, but the lower part has only the pericardium intervening between it and the sternum. The chief anterior relations of the heart are thus with the thoracic wall and thymus. The heart is situated midway between the cephalic and pelvic extremities of the foetus, but with regard to the spinal column, its central point is nearer the upper than the lower end of the latter.

The aorta rises as high as the second thoracic vertebra (at which level the innominate trunk is given off), and reaches the vertebral column at the level of the fourth thoracic vertebra. Here the oesophagus passes forwards to the middle line from the left side, then rather to the right side, and at the level of the 9th thoracic vertebra the oesophagus pierces the diaphragm. When the abdomen is opened, the constituents of the umbilical cord will be seen diverging, the umbilical vein passing upwards, the urachus downwards, and the hypogastric arteries downwards and laterally outwards.

The liver (Fig. 126) is relatively great in size, the left lobe
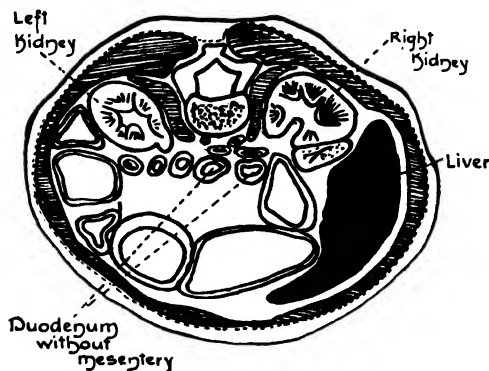
Fig. 126. Section through the abdomen of a human infant (at birth); the lower surface of the section is shewn. There is no duodenal mesentery.

being especially remarkable, for it obscures the stomach. The stomach is situated on the left side of the body, the pylorus being immediately in front of the centrum of the first lumbar vertebra.

The stomach is in relation, anteriorly with the left lobe of the liver, and posteriorly with the spleen, the tail and body of the pancreas, the left suprarenal body, and the upper part of the left kidney.

The pancreas has similar relations to those which obtain in adults, but does not touch the left kidney. The line of mesenteric attachment is almost horizontal : the caecum is variable in position, and has by no means always reached its permanent locality in the iliac fossa, though frequently found here.

The supra-renal bodies are of relatively large size, and the chief difference between their relations in infant and adult consists in the fact of their covering more of the surface of the infantile kidney. The position of the latter with regard to the vertebral column is indicated in the diagram (cf. Fig. 124); renal lobulation is still distinct, and there is a difference as regards anatomical relations from the adult, the embryonic kidney being covered to a larger extent by the supra-renal bodies. The ureters open into the bladder at the level of the pelvic brim. The bladder, when not distended, has the form of a simple tube : when empty, it extends to about 25 mm. above the symphysis pubis, and when full (in the new-born infant), may rise above the level of the umbilicus. Anteriorly no peritoneal pouch separates it from the abdominal wall : but posteriorly the peritoneum passes down till it comes into relation with the prostate gland. Behind the bladder there may be, in addition to the rectum, coils of small intestine, or a portion of the sigmoid flexure of the colon, or the rectum alone may be found. In the female the uterus intervenes. In the pelvis are found the rectum, the prostate gland, and sometimes a loop of the sigmoid flexure. On the rectum the peritoneum descends to the level of the fourth sacral vertebra. In female infants the uterus is an abdominal organ in its upper half or third, the ovaries also lying above the level of the pelvic brim, but the vagina must be added to the pelvic contents in the female. The urinary meatus in the female is 10 mm. in front of a perpendicular line drawn from the lower end of the symphysis pubis.

(ii) The topographical anatomy of the foetus at the middle of intra-uterine life may be partially illustrated by the diagram submitted for comparison with that of the ninth month foetus (v. Fig. 124). It will be noticed that the general result of the

observations is to shew that the various organs and structures occupy levels rather higher at the end of the fourth month than at the end of the ninth. A special note must be made with regard to the cerebral hemispheres, which do not overlap the cerebellum so completely as at the end of foetal life, though in the case examined they overlapped the mid-brain (cf. Fig. 127) (contrary to the description of Ballantyne, *Foetal Pathology*, p. 87). The cerebral opercula are still rudimentary, leaving the central lobe
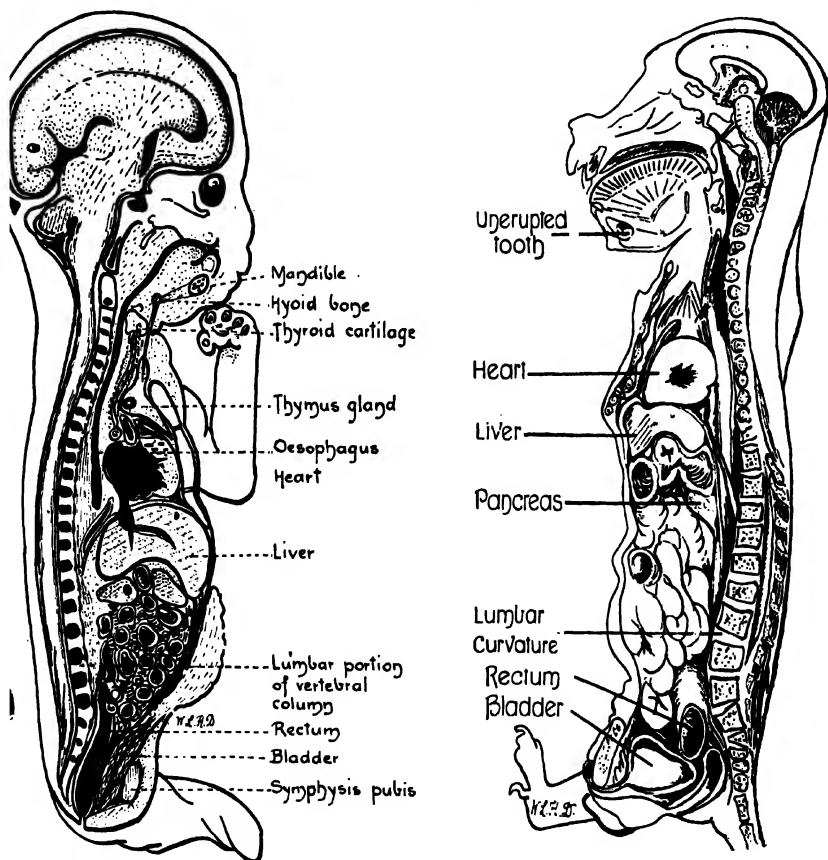
Fig. 127. Mesial section (A) of a human foetus at about the end of the 5th month of pregnancy. It is convenient to compare with this the corresponding section (B) of an adult cynocephalous monkey.

(Island of Reil) freely exposed on the cerebral surface (Fig. 128), and to judge from Cunningham's preparation of the head of
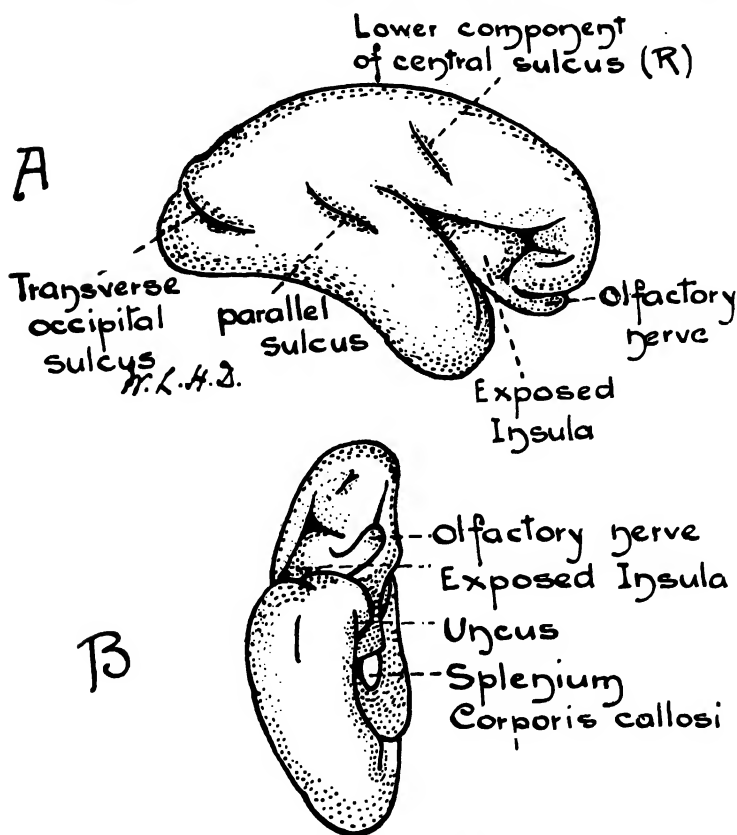
Fig. 128. Lateral (A) and ventral (B) aspects of the right cerebral hemisphere of a foetus of five months.

a foetus at the sixth month, the central lobe is covered more by the frontal than by the parietal bone, owing to the more rapid development of the frontal element up to this stage. The supra-callosal part of the hippocampus is distinct (cf. Fig. 129), and forms the stria of Lancisi.

Conclusions from topographical anatomy. The conclusions from the topographical anatomy of the foetus will not differ appreciably whether the earlier or the later stage be considered.

They amount to the statement that in each case there are differences in topographical relations from the adult condition, and that some of these differences constitute resemblances to those obtaining
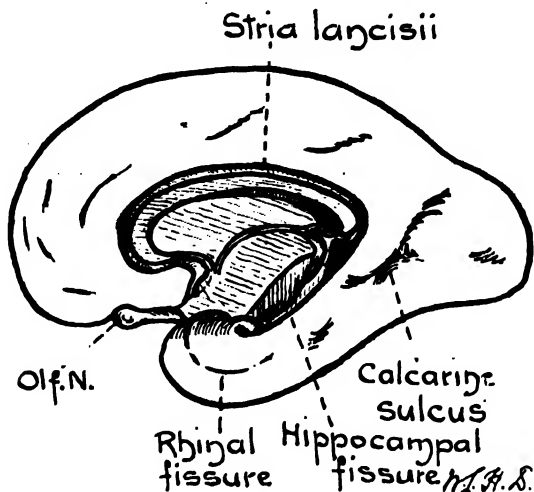
Fig. 129.   Mesial aspect of the right cerebral hemisphere of a foetus of slightly greater age than the preceding example.

normally in the lower Primates.   For instance, it is remarkable that while the obliquity of the posterior limb of the Sylvian fissure (cf. p. 162) is in the ninth month foetus different in degree from that of the adult human being, this very difference is one that associates the foetus with the lower Primates.   But it is also noteworthy that the association is with the lower Primates, and not with the higher members of that order, i.e. it is with the Cercopithecidae, and not with the Simiidae.

Again, in the incompleteness of the opercular coverings of the central lobe of the brain, the fifth-month foetus and the ninth-month foetus, while differing from the human adult, resemble lower forms, not only of the Primates, but of other Eutherian orders.   In both the stages of foetal life considered the thorax and the contents of the thoracic and abdominal cavities occupy a position relatively anterior with regard to the vertebral column than in the adult human being (cf. Table on p. 170).   While thus differing from the latter, they agree in resembling certain of the

Table from Cunningham Memoir II. (D. J. Cunningham).

	Adult Male (Braune)	Adult Female (Braune)	Newly-born Infant		Chimpanzee	Orang-utan	Gibbon
			Male	Female			
Tip of the Epiglottis	C. iii. (upper border)	C. iii. (lower border)	Junction of Odontoid with C. ii.	Junction of Odontoid with C. ii.	Junction of Odontoid with C. ii.	Junction of Odontoid with C. ii.	Mid-point of C. ii.
Lower border of Cricoid Cartilage	Disc between C. vi. C. vii.	C. vii. (upper border)	C. iv. (lower border)	C. iv. (lower border)	Disc between C. v. C. vi.	Disc between C. v. C. vi.	—
Bifurcation of Trachea	Th. iv.	Th. iv.	Th. iii.	Th. iii.	Th. v.	Th. iii.	—
Summit of Aortic Arch	Th. iv.	Th. iv.	Th. ii. (upper border)	Th. ii.	Th. iii.	Th. ii.	—
Lower surface of Heart	Disc between Th. viii. Th. ix.	Disc between Th. ix. Th. x.	Disc between Th. vii. Th. viii.	Th. vii.	Disc between Th. ix. Th. x.	Th. vii.	Disc between Th. viii. Th. ix.
Upper limit of Sternum	Th. iii.	Th. ii.	Th. i.	C. vii.	Th. ii.	Th. iii.	Disc between Th. i. Th. ii.
Duodenum	L. iii.	Between L. ii. L. iii.	Between L. ii. (2) L. iii. (3)	L. ii.	L. ii.	Between L. i. L. ii.	—
Bifurcation of Aorta	L. iv.	L. iv.	—	—	L. iv.	Disc between L. iii. L. iv.	L. iv.

General note on the foregoing table.

The orang-utan and human foetus agree in differing from adult human beings in respect of the positions of the Larynx (as judged by the Epiglottis, the Cricoid, and the Tracheal Bifurcation; *v. supra*), of the Heart (as judged by its lower margin; *v. supra*) and of the Duodenum, all being placed nearer the head in the former than in adult man. The evidence from the sections of the Chimpanzee and Gibbon is not clear.

lower Primates, especially the Orang-utan, but not, apparently, the Chimpanzee[1].

The difficulty again meets us that the indications are general and that no special Primate form or forms are indicated as definitely ancestral to Man.   But this need cause but little surprise when it is considered that the modern Primates have all themselves undergone modifications in the course of their descent from the common ancestral forms which we must expect to have indicated to us in the recapitulated evolution (ontogeny) of any one of them.

(c) **Systematic anatomy of the foetus:** (i) *The Skull.* A review of the systematic anatomy of the human foetus at the end of its intra-uterine development may be conveniently commenced with the study of the skeletal system, beginning with that of the skull.   Of the latter it is essential to recognise the morphological divisions into cranial and facial portions, and to note that in several instances, notably in the upper maxillary, occipital, and temporal bones, several elements are recognisable which subsequently fuse to form the continuous masses to which the respective names are severally applied.   In most cases the sutural lines are straight, the adjoining bones being barely in contact.   The bulk of the cranial portion of the skull is greatly in excess of that of the facial part (and though this is an anticipation, it must be remarked that in this, perhaps its most striking feature, the foetal skull departs further from the simian form than does that of the human adult).

The cranial arc is well developed, and measures nearly four times the length of the cranial base, a proportion which is subsequently only slightly modified (Ballantyne's figures are not quite corroborated by mine: comparison, Ballantyne gives the following; foetus 3; adult 2·8 to 2·7; while I found the following: foetus 3·9: adult 4·1; a chimpanzee 2·2)[2].   The actual dimensions of the foetal skull have already been mentioned (cf. the section on topographical anatomy, p. 162).   In form, very considerable variations may be met with as a result of difficult parturitions, and on the whole there

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[1] See note on topography, p. 170.
[2] Turner's figures are (*J. A. and P.* Vol. xxxv.): 20 ♂ Australians 2·7, 20 ♂ Scots 2·8, a gorilla 1·9, a chimpanzee 1·7.

seems fairly distinct evidence that antero-posterior elongation is usually produced, though this is usually transitory (cf. Gönner).

When the foetal skull is viewed from above (Fig. 130), the following points are to be noticed: the frontal element is smaller than in
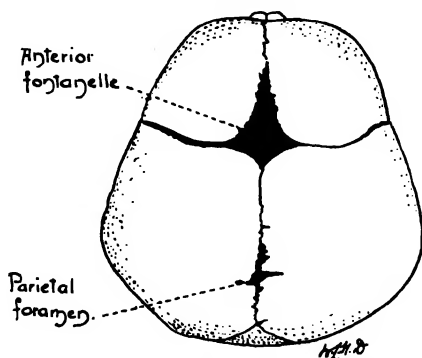
Fig. 130.   The skull of a foetus at the ninth month, viewed in norma verticalis.

the adult; muscular ridges are absent; the parietal eminences are very outstanding; and the zygomatic arches are not visible (the skull is cryptozygous).   Turning to the facial portion of the skull (Fig. 131), the lack of prognathism owing to the small size of the
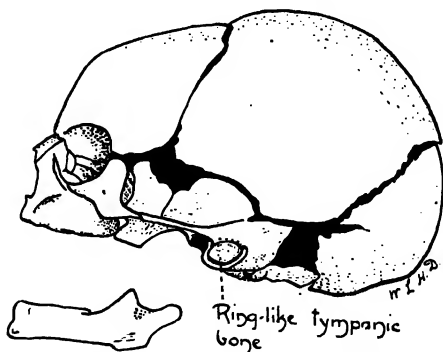
Fig. 131.   The skull of a foetus at the ninth month, viewed in norma lateralis.

upper maxilla (the antrum is small also) is noticeable; the profile is flattened, partly owing to the flatness of the nasal bones.   The mastoid process is not yet developed and the tympanic bone is a shallow, imperfect annulus.   The alisphenoid does not extend far

upwards, and the ascending ramus of the mandible is characteristically short. Viewed from in front, a well-rounded transverse cranial arc is seen: but the facial skeleton is narrow in comparison with the broad appearance of the face when covered by the soft tissues. The interorbital space is wider than in adults according to Blind[1]. The last-mentioned author's statements that the frontal ends of the nasal bones are usually narrower in proportion to their lower ends in the new-born, must be received with caution: in a certain number of cases such narrowing is marked (the shape then being comparable to that in the Gorilla, though Blind erroneously compares it to that of the Orang-utan): again, the upper and lower diameters may be equal, and then confer an appearance designated the Hylobates type (Blind). The inferior nasal margins are quite indistinct (Prenasal grooves 22 %, Blind). As regards the nasal aperture, very exaggerated platyrrhiny, i.e. great width as compared with height is the rule (index from 79 to 50; the mean being 62·2, Blind). On the facial surface the premaxilla has already fused with the maxillla.

Viewed from below, the palate presents an hypsiloid (U-shaped) contour; the spheno-maxillary fissure is wide; the glenoid fossa shallow; the anterior lacerate foramen widely open; and there is marked projection of the occipital end of the skull beyond the foramen magnum, which is therefore central in position. Viewed posteriorly, the cranial contour is often nearly circular, and the divisions of the occipital bone are seen. The flatness of the condyles results in their being overshadowed by the squamous part of the bone. As regards the endocranium, the presence of the floccular fossa beneath the superior semicircular canal is to be noted. There is a suture—the petro-squamous—crossing the roof of the tympanic cavity.

The vertebral column. In the vertebral column a striking character is the mobility which enables the foetus to adapt itself to its confined surroundings: at the same time this mobility and flexibility render an exact estimate of the characters of the curvatures of the column a matter of great difficulty. It must be admitted that the statement (Ballantyne, *op. cit.* p. 106) is justified, which reduces the curvatures to two, both concave forwards, and

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[1] *Op. cit. v.* p. 157 *supra.*

separated by the prominence of the upper sacral margin[1]. The cervical portion is relatively to the lumbar portion longer than in the adult (cervical $18\,^0/_0$; thoracic $40\,^0/_0$; lumbar $22 \cdot 5$; sacrococcygeal $19\,^0/_0$). Macalister (*Human Anatomy*, pp. 114, 130) makes two statements regarding these proportions. Thus in one connection the proportions (per cent.) are stated to be C. 18, Th. 45, LS. 37, and a few pages later we find the same proportions stated as C. 21, Th. 39, LS. 39, in both cases in the new-born infant. The inference is that the range of individual variation is extensive. For adults, the percentages given by Macalister are C. 16, Th. 40 for males (39 for females), L. 25, S. 19.

The anterior arch of the atlas is still cartilaginous, and the spine of the seventh vertebra not yet specially prominent.

The vertebral centra in the lumbar region have not yet attained the characteristic breadth seen in the adult bones. As regards the sacrum however there seems little doubt but that it presents its characteristic of breadth from the fourth month of foetal life (Thomson).

The ribs are rather more horizontal than in the adult (*v. supra*, page 164); the section of the thorax below the axillae is shewn to be nearly circular by the high figure representative of the thoracic index (the percentage relation of the antero-posterior and the transverse diameters), and this constitutes a quadrupedal, if not a definitely simian resemblance.

In this connection the foetus must be distinguished from the new-born infant, for the inflation of the lungs with air will naturally react to some extent on the form of the thoracic cage.

The sternum is flattened, and in this respect does not differ from that of the adult. The subcostal angle is said to be more open (100° than in the adult, 67° to 80°).

Upper limb girdle. The scapula has much the same form as in the adult, though owing to the softness of its substance in the

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[1] Balandin (*Virchow's Archiv*, 1873), excepts the cervical region, which he describes as straight. Macalister (*Human Anatomy*, p. 129) makes the following statement. "The primary curve is the dorsal curve of accommodation, concave forwards, the remains of the primitive embryonic curve, and present from the earliest period. The sacral curve is also a curve of accommodation for the pelvic viscera, and appears about the fifth month of foetal life." But Cunningham shews that the sacral curve appears before the fifth month, *v. infra* p. 182, footnote 1.

foetus, exact comparative measurements are not easy to make. Judged by the scapular index, its proportions are certainly different from those obtaining in the adult, and constitute a condition resembling those found in the lower Primates and quadrupedal mammals.

Lower limb girdle. The sacrum (cf. Fig. 132) has been already mentioned: its anterior surface is almost plane and the sacral alae are incompletely developed, so that the appearance of the bone is elongated. Nevertheless, Thomson states that accurate measurements shew that this appearance is misleading, and that
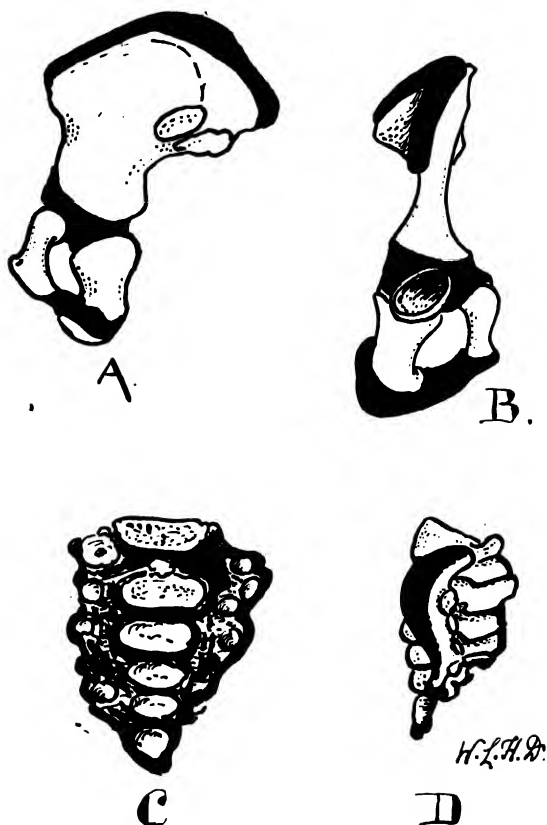
Fig. 132. The os innominatum (A ventral and B side view) and sacrum (C ventral and D side view) of a foetus at the ninth month.

the real increase in width is provided for chiefly by the growth of the posterior parts of the iliac bones.

The ilia (cf. Fig. 132) are much splayed (as in Simiidae) and anteriorly the iliac fossae are scarcely recognisable. The proportions of the pelvic brim have been carefully investigated by Thomson[1], who states that the commonly-accepted account (which assigns a greater length to the sagittal than to the transverse diameter), is incorrect, the reverse being the case, so that the proportions are similar to those which obtain in the adult pelvis, and different from those of Simiidae and most lower Primates and Eutheria.

Ballantyne's results do not altogether confirm these, so that the proportion is probably a variable one. It seems established that sexual differences in pelvic form already exist, even as early as the fourth month of foetal life, that the male pelvic cavity tapers downwards more suddenly, that the ischial spines are more inverted (12 mm. inter-ischial diameter in males, 14 mm. in females, at the ninth month), and that the male sub-pubic angle (50°) is more acute than that of the female.

Skeleton of the limbs. In the skeleton of the lower limb the angle between the neck and shaft of the femur is greater (160°) than in adult life (125°), the foetal condition thus being the further removed from the quadrupedal one: and that the angle at which the neck of the astragalus is set is smaller than in later life, and consequently suggestive of the simian condition[2].

A special extension of the upper articular surface of the astragalus, supposed to be associated with extreme flexion of the ankle joint, and presumably reminiscent of the squatting position assumed in ancestral forms, is also to be remarked. The external malleolus is longer than the internal, thus resembling the adult malleolus and differing from that of the apes[3].

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[1] *Journal of Anat. and Phys.* Vol. xxxviii.

[2] Bland Sutton, in Morris's *Human Anatomy* ; also Shattock, *J. A. and P.* Vol. xxiii. and *Trans. Path. Soc.* xxxv. 1884; also Sewell, *J. A. and P.* Vol. xxxviii. The internal divergence of the astragalar neck is denoted in the infant by an angle of 30°; in the adult European, of 10°; in the ancient Egyptian adult, of 18°; and in the anthropoid ape, of 27°. Volkov has recently published an important article on this subject: *Bull de la Soc. d'Anthr. de Paris,* 1903.

[3] Keith, *Human Morphology*, p. 315.

Musculature. Little precise information on this subject is accessible. Chievitz (*Topographical Anatomy of the Foetus*, Copenhagen, 1899), has described the course of muscle fibres as being very straight in the foetus just before birth. The following note from Le Double's *Traité des variations du système musculaire* (Tome II. p. 464) is of much importance. "In young children the M. semi-membranosus and semi-tendinosus are prolonged below the knee as in certain lower members of the Primates[1]."

Nervous system. The cerebral convolutions (cf. Fig. 133) are slightly less tortuous in the foetus at the ninth month (or infant at birth) than at later stages, and this is chiefly due to the
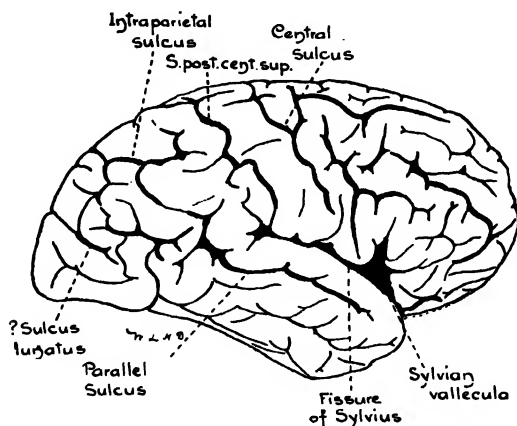
Fig. 133. The lateral surface of the right cerebral hemisphere of a new-born infant.

later development of small secondary sulci which complicate, but do not essentially modify the pre-existing arrangement. With regard to particular features, the general arrangement is so similar to that obtaining in the brains of adults, that the search for distinctive features is a somewhat minute one. All the characteristic fissures and sulci of the adult cerebrum are present; the rhinencephalon is as much reduced as in the adult brain: the

Fascial extension is probably indicated. W.L.H.D.

Rolandic angle (between the median longitudinal inter-hemispheric sulcus and the central sulcus) is not appreciably different from that of the adult brain. With regard to the Sylvian region and fissure, it is to be noticed that the central lobe is not always completely operculated: the point at which the stem of the Sylvian fissure reaches the outer surface of the hemisphere is situated relatively further back in the human infant (and the Catarrhine apes) than in the human adult. The angle of the Sylvian fissure (i.e. with a vertical line) is more acute in the infant (and in the Catarrhine apes) than in the adult. As regards other sulci, it will suffice to note that the relative length of the sagittal portion of the intraparietal sulcus is greater in the human foetus than in the adult (the Simiidae varying in this respect, cf. *Cunningham Memoir*, No. VII.). No special remarks can be made with regard to the peripheral nervous system.

Vascular System, and associated systems and organs. The heart is (relatively to the body-weight) heavier in the foetus, and the right ventricular wall (relatively to the left) is thicker. The foramen ovale is patent, and the valve of the fossa ovalis, the valve of Vieussens, the Eustachian valve, and the valve of Thebesius are all distinct. The ductus arteriosus is conspicuous, overshadowing the pulmonary arteries; the orifice of aperture into the aorta is guarded by a valve and is peculiar in being oval in form (Strassmann, quoted by Ballantyne).

The umbilical arteries overshadow in point of size the external, and indeed the internal iliac vessels. As regards the venous system, it is to be noted that the vena cava superior is short, and is vertical in direction. The left innominate vein is nearly transverse in direction and is covered by the thymus. The latter body is as broad as it is long, and is usually bilobed, with an inconstant median lobe. No peculiarities of the lymphatic system or thoracic duct seem to be known.

Ductless glands. The thyroid body differs in no important external features from the adult organ. Of the characters of the spleen but little seems to be known; it has a large area of contact with the left supra-renal body. The supra-renal bodies are

relatively large (the right larger than the left), they are pyramidal in shape, and extend as already mentioned, far over the anterior renal surface.

Respiratory System. The high position occupied by the larynx has already (p. 170) been noted. The trachea is flattened antero-posteriorly. The distinctive characters of the lungs depend upon the lack of inflation in the act of respiration; the right lung is larger and heavier than the left. After respiration has been established, all the pulmonary diameters increase, and there must be a considerable degree of expansion downwards, to judge by the amount of space in the lower parts of the thoracic cavity (between the diaphragm and the parietes) unoccupied by lung before this occurrence: before respiration too, the lungs have a liver-like consistency, do not crepitate, little or no blood oozes out under an incision, and when firmly squeezed under water, they yield no air-bubbles (Ballantyne). But these phenomena do not essentially affect morphological comparisons. No lobus azygos impar is seen.

Alimentary system. The stomach is small and more cylindrically elongated than in the adult; the lesser curvature is directed
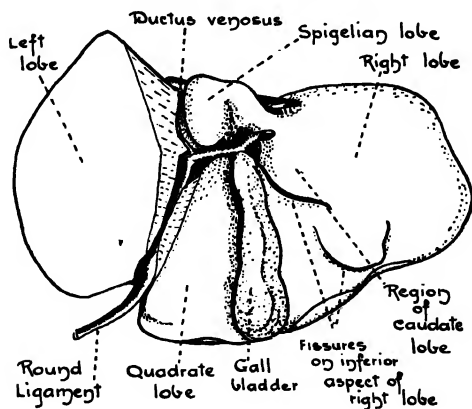
Fig. 134. The liver of a human foetus at the ninth month; the inferior surface is shewn.

downwards, first parallel to the side of the vertebral column, and then transversely to the right across that structure. There is no

vestige of a duodenal mesentery, so that the permanent human condition has already been attained; the vermiform appendix (cf. Fig. 135) is present. The ascending colon has no meso-colon, the sigmoid flexure (omega-loop) is distinct, and the rectum is straighter in direction, and thus more simian, than in the adult.

The Liver. (Fig. 134.) The large size of the left lobe of the liver has already been noticed. Passing over the various anatomical relations of the organ, it is to be noticed that there is no trace or suggestion of subdivision of the left lobe; on the inferior surface of the right lobe however, certain small fissures may occur, which are not seen in adult livers; suggest the fissured condition of this part of the liver in gorilla (Thomson)[1].

Genito-urinary system. The kidney (which shews traces of lobulation) is found on section to possess several pyramids; it thus resembles the adult organ, and differs from the kidneys of the lower Simiidae and Anthropoidea. The bladder is somewhat tubular in form. In the male the prostate is distinct; the testicles are in the scrotum. In the female, the cervix uteri is relatively thicker and longer than the corpus, and the rugae may be prolonged to the fundus: rugae may also be seen on the vaginal aspect of the cervix: the os is sometimes patent: the Fallopian tubes are sinuous, the ovaries lie above the pelvic brim, and are elliptical, shewing many follicles on section. The vagina is relatively long, vertical in its upper part and turning only slightly forwards at its lower end.

Fig. 135. Caecum, with vermiform appendix, of a human foetus at the ninth month.

Thus the female organs of generation differ markedly in the foetus at nine months from those of the sexually mature individual, but

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[1] *J. A. and P.* Vol. xxxiii.

with the exception of the vagina, none provides distinct evidence of simian resemblance.

Systematic Anatomy of the human foetus: (ii) *The skeleton. The skull.* (Cf. Figs. 136, 137.) The spaces between the several cranial bones are widely open; ossification has commenced in the cartilage of the auditory capsule. The post-orbital wall is not yet fully formed, owing to the non-development of the orbital portion of the alisphenoid, and the adjacent part of the malar bone. The lacrymal bones are relatively large, as compared
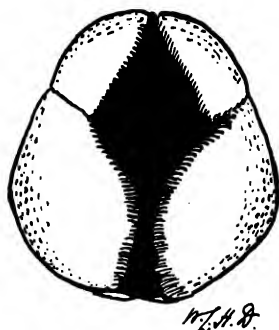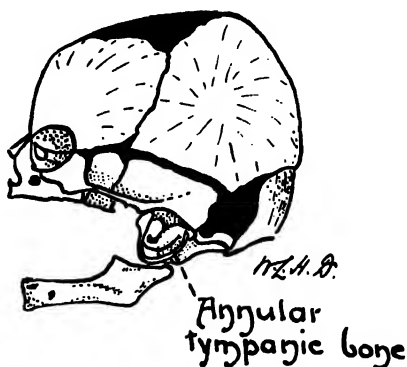
Fig. 136.   Fig. 137.

Fig. 136. Cranium of a human foetus at about the fifth month, viewed in norma verticalis.

Fig. 137. Cranium and mandible of a human foetus at about the fifth month, viewed in norma lateralis.

with later stages. The alveolar portion of the maxilla is practically non-existent. The mandibular symphysis is unclosed, there is practically no distinction into body and ascending ramus, and remnants of Meckel's cartilage are distinctly visible. The foramen magnum is situated on the inferior aspect, not merely on the posterior surface, of the skull. In the nasal fossa, as many as six turbinated bones are recognisable. There is thus a resemblance to the crania of the Simiidae.

The vertebral column. Throughout the whole length of the column the neural arches have just closed: ossific centres are

seen in the centrum and in the odontoid process of the axis
vertebra. The lateral parts of the sacrum are still cartilaginous,
but according to Thomson, this segment is relatively as broad as
in the adult. The vertebral column (cf. Fig. 138) being even more
flexible than at the ninth month, the only constant curves are a
cervico-thoracico-lumbar and the sacral curve[1]. The thorax
presents a circular appearance in section, the sagittal and
transverse diameters being nearly equal.
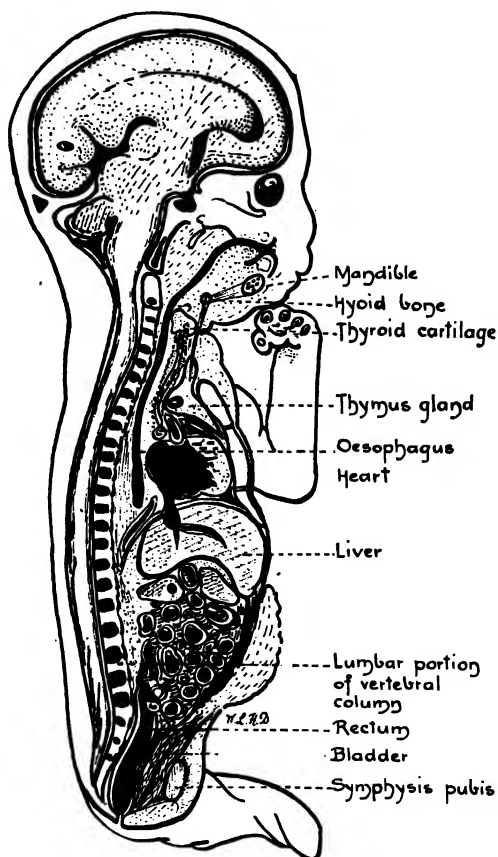
Fig. 138. Mesial section of a human foetus at about the fifth month of
pregnancy.

[1] *Cunningham Memoir* ii. p. 76, Fig. D. Embryo of 46 mm.

The skeleton of the limbs. The clavicle is relatively large (and herein is a simian resemblance) differing thus slightly from that of the ninth month foetus and the adult. The scapula is but partly ossified. The proportion of scapular breadth to length is about 80 % (at $4\frac{1}{2}$ months: at the 4th month it is 84·6 % = scapular index). The olecranon fossa is rudimentary, and the diaphyses of the shafts of the limb bones only are ossified. The os centrale has already joined the os radiale carpi. The pelvis is fairly wide in appearance, but the brim is variable in proportions owing to the soft nature of the pubis. The ilia and ischia are partly ossified, and according to Thomson, sexual differences are already distinguishable.

The femoral diaphysis has a slight convexity forwards and in the early part of the third month is almost equalled in length by that of the tibia. The fibular diaphysis extends lower than the tibial one but no definite description of the comparative sizes of the malleoli is possible at this epoch, despite the (quoted) account given by Keith[1].

Both in hand and foot, the ossific centres in metacarpus, metatarsus and phalanges stand out in striking contrast to the comparatively soft-tissued carpus and tarsus.

Musculature. Judging from the figures published by Lewis in the *American Journal of Anatomy* (Vol. I.), the muscular attachments appear, at an even earlier stage than that considered here, to have assumed their definite and permanent characters. The special case of the tendon of the long head of the M. biceps humeri must be particularly mentioned. At the sixth month, this tendon has sunk into the capsule of the shoulder joint (to which it was at first external) and is enclosed with a special envelope derived from the joint synovial membrane (cf. Macalister, *Text-book of Human Anatomy*, p. 286). The case of the M. flexor longus pollicis is of interest also. Lewis (*op. cit. supra*) states that in the human embryo, this muscle has early acquired its independence of the general deep flexor mass of muscle: nevertheless the drawing in Fig. C, Plate II. of the article referred to, strongly suggests the community and fusion of the long flexor of the thumb with the

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[1] *Human Morphology*, p. 315.

long flexor muscles of the other digits at the epoch in question, viz. about the 7th week.

The central nervous system. The limits of the rhinencephalon (Fig. 139) on the ventral surface are quite distinct, and the olfactory nerve is relatively large and stout; bending sharply outwards at its posterior end and close to the central lobe (insula), it may now be described as an olfactory tract which is continuous with the region of the temporal lobe subsequently recognisable as the uncus. The cerebral hemispheres are characteristically devoid
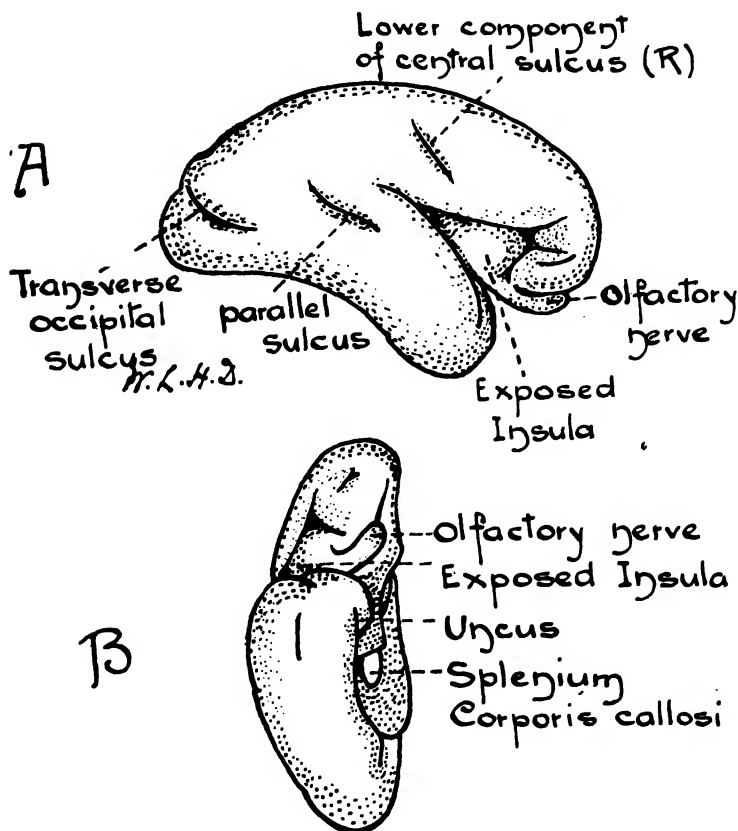
Fig. 139. Two views of the right cerebral hemisphere of a human foetus of about 5 months : A, shewing the exposed insula, and the paucity of sulci; B, to shew the close connection of the olfactory nerve with the lower part of the insula.

of sulci[1], especially on their cranial aspect: on the mesial surface there may be distinguished, the hippocampal fissure, the calcarine and less constantly the internal parieto-occipital sulci. The Sylvian opercula are quite rudimentary and bound a widely open Sylvian vallecula or fossa. The occipital extent of the hemispheres is far from complete, and the corpus callosum is distinct, though also incomplete in backward extent. (Some discrepancy as to this exists in the several accounts; cf. especially Kollmann[2], Fig. 322; and Minot[3], Fig. 392, both from Marchand).

Transverse grooves are beginning to appear on the surface of the cerebellum.

Vascular, respiratory, alimentary and genito-urinary systems. In position, the heart is more mesial than at later stages, the inter-ventricular septum has already been long closed. The thyroidal acini are in places still solid masses of cells. The thymus and supra-renal bodies are relatively much developed in point of size, but the pituitary body is not conspicuous in this respect. Apart from topographical relations, there is little to note in the respiratory system. There is a rudimentary lobus azygos impar at the root of the right lung and the correspondence of the upper lobes of the two lungs has been pointed out by Minot[3], p. 776.

[1] The fissures called "transitory" seem to be proved to owe their origin to decomposition and to the uneven action of the preservative fluid. Mall's article in the *Am. Journal of Anat.* (Vol. II. p. 333) gives the most recent literature. Genuine sulci seem to be equally deficient on the cerebral surface of the foetus of Gorilla at a corresponding epoch. Only one specimen is however known, viz. that in the Zoological Museum of the University at Cambridge. The nature of the causation of the transitory fissures was still under discussion in April 1904, at the meeting of the German Anatomical Society at Jena, and in a work published in the same year, Professor His shewed that he had not yet relinquished entirely a belief in the view that these are veritable fissures and not artefacts.

It remains to indicate a point of interest concerning the fissura perpendicularis externa (Bischoff). This fissure or sulcus is of common occurrence in the brain of the foetus at about the fourth month; corresponding, as it does in position, to the "ape-fissure" of the brains of Simiidae and other Primates, its appearance was thought to mark the simian epoch in the development of the human brain, and its subsequent disappearance claimed as a sign that the epoch in question had been passed. But Elliott Smith has shewn that the sulcus is really due to the imprint of the posterior margin of the parietal bone. (Cf. *Anat. Anz.* Bd XXIV. No. 8.)

[2] *Entwick. des Menschen.*

[3] *Human Embryology.*

The tonsils are just apparent, and muscle fibres are being differentiated in the stomach wall. The vermiform appendix (Fig. 140) is quite distinct, and by the commencement of the fifth month has been seen in the iliac fossa. (The sigmoid flexure is quite clearly differentiated also and the rectum pursues a straight course.) The liver (Fig. 141) is very large, and its left lobe extends far enough across the abdomen to touch the spleen: but neither right nor left lobes are subdivided in the
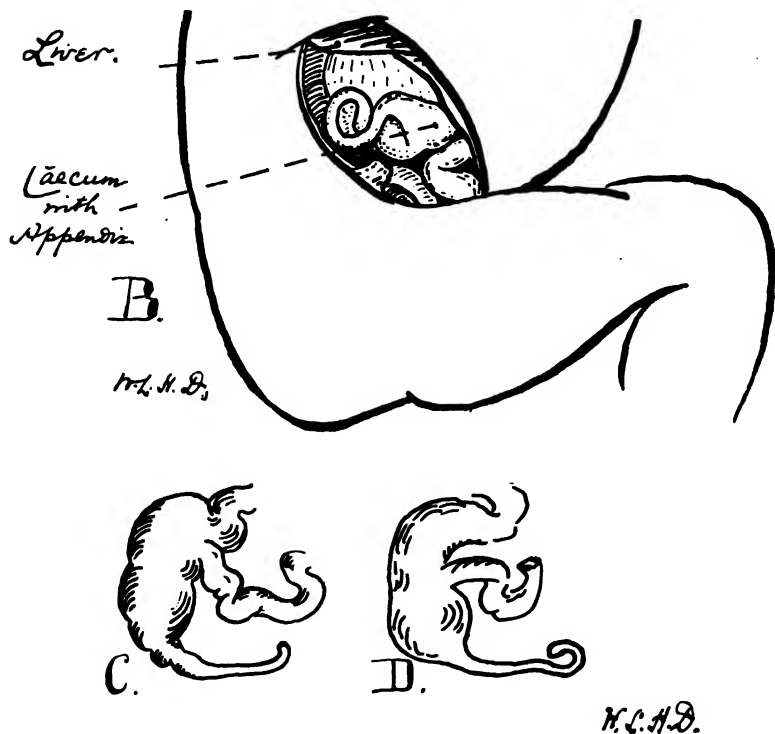
Fig. 140.   Right lateral aspect of the abdomen of a human foetus of about 5 months; the caecum with its appendix is exposed; the final position of both will be lower and some circumduction of the latter may occur in later stages.

(Catarrhine) ape-like fashion. Several papillae project into the pelvis of the kidney, which is very large and lobulated. The testes are abdominal in position, the gubernaculum is distinct, and the
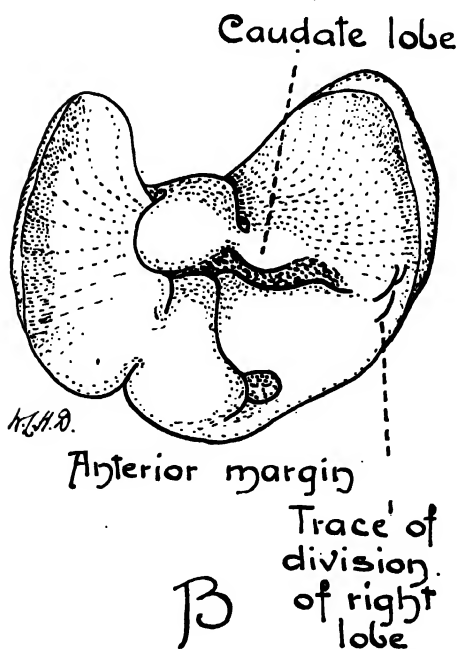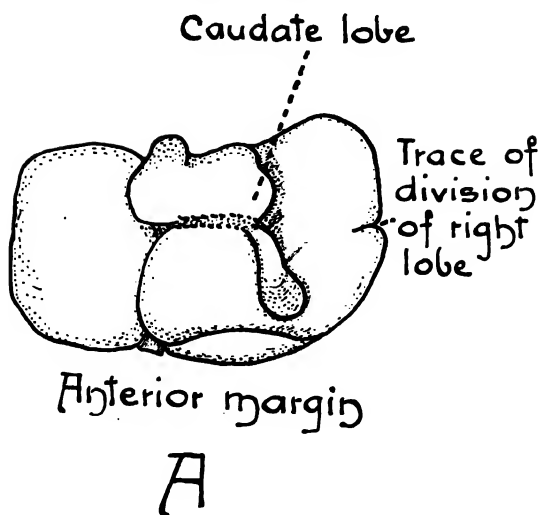
Fig. 141.   Livers of two human foetuses at about the 5th month.   In neither is the caudate lobe so distinct as in the Cercopithecidae, nor is the quadrate lobe yet detached from the (parent) right lobe.   (*A* is a spirit specimen, *B* has been preserved in Muller's fluid and shews the true form of the organ.)

prostate can be identified. In the female, the lumen of the vagina is closed.

The enamel-organ of the deciduous teeth is now differentiated.

Conclusions from the study of foetal systematic anatomy at the ninth month. When the general characters of this, the most advanced foetal stage in Man, are reviewed with the object of examining evidence bearing upon the question of Man's more immediate ancestry, it seems as though the observations may be arranged in three groups. First of all, there are to be noticed characters, such as the relatively large size of the liver, of the hypogastric arteries, or of the fontanelles, which appear to be quite irrelevant; these are in fact, conditions associated with, and determined by the particular and peculiar mode of development in the higher Eutheria, and therefore they may be expected to obtain in all these animals alike[1]. Secondly, there are a number of characters, such as the great size of the head and of the cerebrum, which are related to the specific and peculiar characters of the Hominidae, and which might well be expected to be so impressed in their organization as to appear, prematurely, so to speak, in his individual development, just as in all Amniota the brain is early differentated, grows with precocious energy, and rapidly attains an apparently disproportionate size. The establishment of these two categories leads to the recognition of the fact that a very considerable number of the characters of the ninth-month foetus cannot be directly applied to the elucidation of the problem of human descent, and that indeed they must be eliminated with great care. They lead however to the conclusion that at this epoch, human peculiarities are perfectly patent and strongly imprinted.

But when due allowance has been made for the occurrence of such characteristics, there remains a residue of observations which may be collected and associated in a category of pithecoid affinities. The flatness of the nose, the imperfect power of opposition of the pollex (shewn by the mode of grasp in the new-born infant), the straighter lumbar column, the flattened sacrum, the imperfectly extensible hip and knee, the proportionately long upper limb, the

[1] See note on page 189.

¹ The following statements bearing on Muscular Ontogeny are given by Dr Le Double in his book on *Variations in the muscular system*.

The Muscle	Condition from birth onwards	Condition in foetal and embryonic life
1. Platysma myoides.	Limited to the Cervico-facial region.	1. Universally distributed as in most Mammals, and in birds (as shewn by Milne-Edwards, Sappey, etc.).
2. Diaphragm.	Muscle undivided, with a central aponeurosis.	2. In early stages composed of pre-cardiac and post-cardiac portions as in fish and reptiles. (See His' researches.)
3. Radial Extensors.	Subdivided: two extensores carpi radiales remain.	3. Undivided: and thus corresponding to the extensor carpi anterior of lower animals. (See researches by Humphry, Macalister and Le Double.)
4. Long head of the Biceps humeri.	Attached to glenoid margin and enclosed in joint cavity.	4. At first is inserted into the humerus and lies outside the capsule, but later it perforates this, and before, becoming free, possesses a Meso-tendon, as in the Chimpanzee, in the Cat, in Bats, Dogs, etc. (Cf. Welcker and Müller.)
5. Tendon of Peroneus longus.	Attachment to 1st Metatarsal and to ento-cuneiform.	5. Attachment to ento-cuneiform only, as in certain lower animals. (Ruge.)
6. Adductor transversus hallucis.	Distinct from Adductor obliquus and composed of transverse fibres.	6. Fused with Adductor obliquus (i.e. undifferentiated), and composed of radiating fibres as in Orang-utan, Chimpanzee, Pithecia hirsuta, Hapale penicillata, etc. (Ruge, Brooks.)
7. Opponens and Flexor brevis of small toe.	More or less distinct from one another.	7. Not differentiated: but fused as in all Mammalia save Carnivora. (Cunningham.)
8. Dorsal Interossei of the foot.	Bipenniform, and truly dorsal in position.	8. Simply penniform and plantar in position, as in Canis, Dasyurus, Inuus nemestrinus, and Cynocephalus anubis. (Ruge.)
9. Subhyoid Musculature.	Quadri-partite, viz.: Sterno-hyoid, Sterno-thyroid, Thyro-hyoid, Omo-hyoid.	9. Undifferentiated stratum: similar to that in lower animals, e.g. Sciurus, and Uromastix platydactylus. Note also that Keith (quoted by Parsons) states that in young foetuses the two anterior bellies of the digastric muscles arise from a subhyoid tendinous arch as in cynomorphous monkeys.

incurved feet (and, in the female, the straight vagina), may be
mentioned as features of this kind, which definitely support the
theory of an ancestry inclusive of ape-like forms.   Further,
though the evidence is not yet so complete as could be wished,
there is no reasonable doubt but that the associations are with the
Simiidae rather than with their lower congeners among the
Primates, due account being taken of resemblances first to one,
then to another of the lowlier forms in that Order.   Among the
Simiidae, it is difficult to choose between the three larger forms,
but, again upon the whole, the associations with the Chimpanzee
are maintained longer than with the remaining examples.

    And upon these considerations the view is based, that of living
animals, this (the Chimpanzee) represents, not necessarily very
closely, but on the whole more nearly than any other, that com-
paratively late human ancestor, which were it still in existence in
an unmodified form, we should be induced to associate morpho-
logically with the Family Simiidae, while excluding it from the
Family Hominidae.

    Conclusions from systematic anatomy at the fifth month.
When we pass to the earlier stage of foetal existence, the con-
ditions are somewhat altered as regards our estimate of the
evidence.   For in passing to the middle of intra-uterine de-
velopment, we have retraced the individual back to a stage at
which the group of characters expressive of the mechanical and
physiological conditions of embryological growth are more promi-
nent than at the later epoch.   Examples of such characters have
already been given, to which may be added for the sake of
illustration, such phenomena as the cartilaginous condition of
the tarsus and carpus, and the intra-abdominal position of the
testes.

    Combined with these, the specific human characters are
asserting themselves, and combined with those of the preceding
group, leave but a very small residue of features upon which
to base conclusions as to the exact phylogenetic path of Man
through the Primate phase.   So small a minority indeed is it,
that we are at a loss for evidence to enable us to assign to Man
ancestors represented by any forms taken from the Primates im-

mediately below the Simiidae. A more detailed exposition and enumeration of details, and a more subtle analysis of their import, may yield this information at a later date, but for the moment we have to admit that the problem remains unsolved.

Examination of the human foetus at the mid-term of its development having provided an imperfect response to our enquiry, it is but natural to pass still further back, and to take up the question of the very earliest stages of embryology as affecting Man, and to review, however briefly, the available information, which will therefore form the subject of the next chapter.

CHAPTER VIII.

IN entering upon the consideration of the early embryology of Man and his nearest allies, it may be remarked again (cf. Chapter I. page 11) by way of introduction, that upon the general similarity in the embryological processes in Man and other Eutheria, have been based arguments as to the community of origin of these mammalian forms. One of the early triumphs of embryological investigations was the demonstration that the process of development consists (in its early stages) in the evolution of a multicellular from an unicellular organism. In the unicellular condition, the several mammals closely resemble each other, the chief differences at present demonstrable being those of size. As the process of development advances, the various forms are found to resemble each other for a longer or shorter period according as they are more or less nearly related.

Passing now to a later epoch in the history of embryological discovery, we may refer to the state of that science in so far as it bears upon the development of the higher Eutheria, at the time (1863) when Huxley was delivering the course of lectures on "Man's Place in Nature." At that date, Huxley was able to state, that for 30 years past it had been known that the human embryo pursued a path in development which ran parallel to, if it did not coincide with, that for instance taken by the embryo of a dog, during a very considerable period in embryological history. Facts and illustrations were adduced in support of this statement.

Not only is the human embryo similar in appearance to those of other Eutheria, but much general similarity obtains in respect

of the conformation and structure of the embryonic tissues and membranes of both. And it might well appear that where such similarity obtains between the Hominidae and Eutheria of an Order (the Carnivora) far removed from the Order Primates, it would be futile to seek for evidence of the more intimate relations of Man with animals included within the latter Order. In fact we might presume that the evidence, if any were forthcoming, would be of the vaguest description. And yet, even at the time at which Huxley wrote, indications that such a search might not prove altogether fruitless were to some extent forthcoming, and with the progress of embryological investigation a body of facts of not inconsiderable amount has gradually been brought to bear upon the point at issue, as to the closeness of the relation between Man and the higher Primates.

Another suggestive point remains to be dealt with. It is admitted that although in the comparison of the bodies of the developing human individual and the carnivore, similarity can be traced for a considerable distance, yet divergence in certain adjuncts occurs, and is evident even in comparatively early foetal stages. Huxley (in 1863) pointed out three morphological features in which this difference was to be observed. These points are:

(1) the form (in its later stages) of the yolk-sac whence the early embryo draws its nourishment.

(2) the form of the allantois, a protrusion from the embryo which is intimately connected with the outgrowing blood-vessels; the latter spring from the body of the embryo, and are directed towards the maternal tissues, which they penetrate, and so provide for the nourishment of the embyro after the yolk-sac has fulfilled its functions.

(3) the form and disposition of the placenta, the organ in which the interchange of material between the maternal organism and the embryo takes place.

In respect then of the outward appearance and the microscopical structure of these organs, the human embryo is found to possess a distinctive character, which differentiates it from the dog at a corresponding stage. But the important point brought out by Huxley is, that precisely where the human embryo differs from the

carnivore, there it is to be found in agreement with the apes. In the same respects too, the human organism finds itself associated with the higher apes, and differentiated (just as it is from Carnivora) from the lower Primates, from Cheiroptera, Ungulata and other Eutherian Orders. This point being established, we may proceed to investigate the nature and the results of some of the more recent embryological researches on human and simian organisms.

For present purposes, embryology may be conveniently divided into phases which may be entitled chapters, although in reality no hard and fast lines of demarcation are to be drawn, and the distinction of the several phases is made purely and simply for convenience in dealing with a complicated history. With this premise, it is proposed to deal with the subject as far as there are concerned:

(1)   The early history of the events accessible to observation and immediately subsequent to the fertilization of the ovum.

(2)   The history of the formation of that characteristic and protective covering of the embryo known as the amnion.

(3)   The history of the formation and the relations of the embryonic yolk-sac.

(4)   The manner of attachment of the embryo to the maternal tissues, and the mode of nutrition.

Chapter I.   The early history of the events immediately subsequent to the fertilization of the human ovum. During the last forty years an immense number of observations has been added to the store from which Huxley was able to draw. Huxley's description of the changes which the spherical ovum undergoes subsequently to fertilization (changes which consist in an equatorial fission of the sphere into hemispheres, each of which assumes a spherical form and again divides, the process continuing till the single original sphere is replaced by a mulberry-like body (morula), was based upon observations on other mammals than Man, for no observation had been possible in the case of the human ovum. So great are the difficulties in the way of observation, that absolute facts are still lacking as regards the exact details of the history of the human ovum immediately after fertilization, and there is a similar lacuna of observations as regards the higher apes.

Thus it is, that what we have termed Chapter I. of the embryological history of the higher Primates remains still to be written.

When we turn to Chapter II. (the history of the formation of the amniotic covering of the embryo "amnion"), we find that while abundant observations are now available as regards this subject in the embryology of such animals as the Rabbit, Mouse, or Hedgehog (to consider the Eutherian mammals only), yet in respect of the embryos of the higher Primates, information, for the same reasons as are responsible for the vagueness of the earlier events, is here lacking almost entirely. For in all but a very few of the early embryos of Man that have been hitherto available for examination the amniotic covering has been found already completely[1] formed (cf. Figs. 142 and 143). In the exceptions to this remark, of which about eight have been recorded in the space of half-a-century, no embryo was to be seen, and the state of preservation of these specimens was probably not satisfactory as a basis for reliable information.
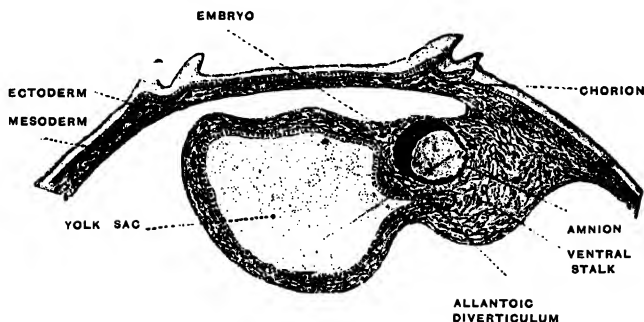
Fig. 142. Diagram of the appearance in section of an early human ovum (from Kollman, after Graf v. Spee). The amnion is complete.

Disappointing though this may be, there are nevertheless observations which throw some light on this part of the history of the embryo. For from the comparison of the Old World monkeys and the higher apes with Man in respect of early development, the close similarity if not the identity of these processes is fully established (notably by the researches of the late Professor Selenka).

[1] This is the case in a human ovum, the estimated age of which is seven days. (Cf. Peters; quoted by Robinson, *J. A. and P.*, July, 1904.)
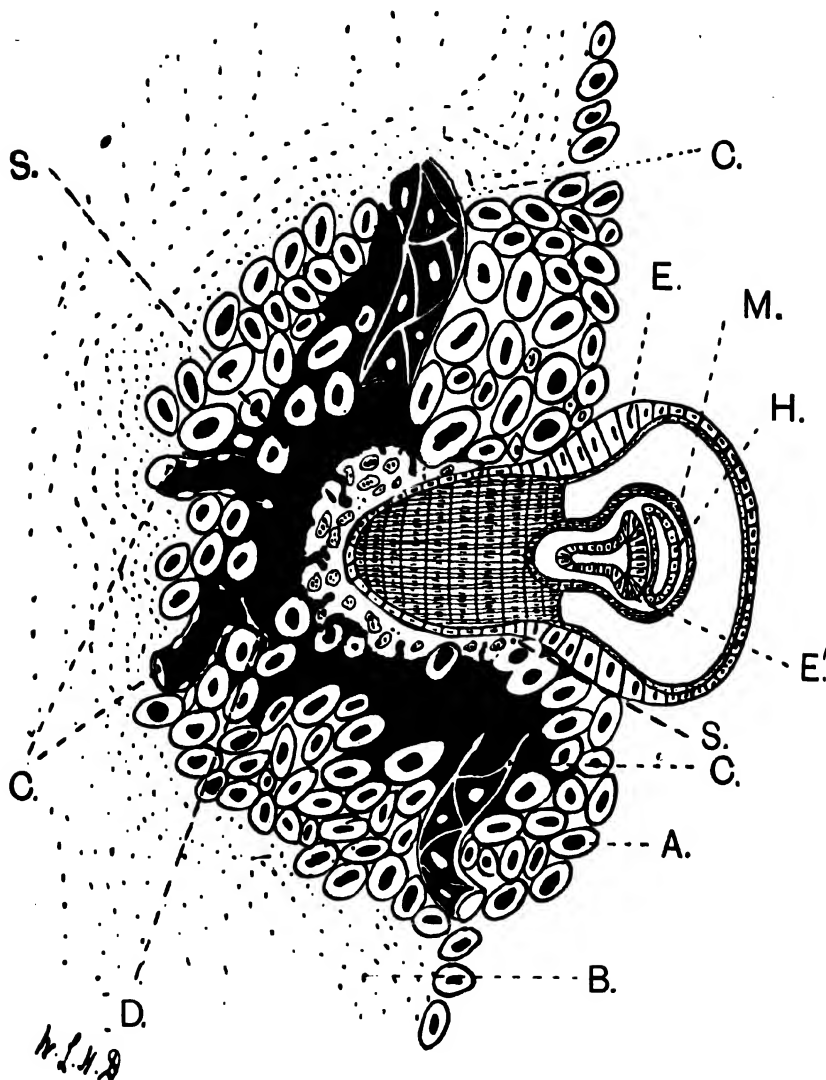
Fig. 143. Diagram (modified from Selenka) of the section through an early ovum of a Semnopithecus monkey, and the adjacent uterine tissues. A general similarity to the arrangement which obtains in the human ovum is here seen. *A.* Decidual cells of uterine mucous membrane. *B.* Deeper decidual cells. *C.* Maternal capillary vessels opening into the intervillous spaces. *D.* Remnant of the wall of a maternal capillary vessel. *E.* Foetal ectoderm (chorionic). *E'.* Foetal ectoderm (non-chorionic). *M.* Foetal mesoderm. *H.* Foetal entoderm. *S.* Syncytium. As in Fig. 142, the amnion is complete.

And as regards the apes, observation leads to the supposition that their early embryonic history is characterised by a very remarkable process affecting the spherical vesicle (blastoderm) into which the morula or mulberry-like mass of cells is transformed. In the first place, this vesicle at a very early period acquires its attachment to the maternal tissues, and presumably takes its nourishment from these, instead of prolonging the period of nutrition from its own original yolk material. Such precocity in attachment to the maternal tissues constitutes a mark of distinction shared by apes and a comparatively small number of mammals.

In the second place, the blastodermic vesicle subsequently appears to undergo a process termed "inversion," by which one part of its surface is depressed and invaginated into the other part, the form thus changing from that of a hollow sphere to that of a cup-shaped hemisphere with double walls. (Cf. Fig. 144.)
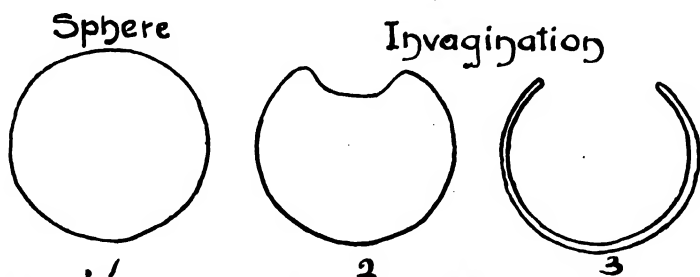
Fig. 144. Diagram representing the process of inversion of the germinal layers.

The process of "inversion" has been clearly observed in such rodent animals as rats and mice, but its progress has not been actually noticed in the apes, though Selenka has figured cases which suggest its occurrence most strongly; even in the Hominidae "inversion" was suspected as long ago as 1889 by Graf von Spee: nine years later Selenka's observations lent great support to his view: and finally in 1900, Mall (cf. Fig. 145) described a human embryo whose appearance, it is believed, leaves no doubt as to the occurrence of this process in Man. The phenomenon of inversion confers on the embryos of the Hominidae and higher Primates a mark.of distinction shared, as stated above, by a few mammals only.

Into the details of the phenomena it would be impossible now to enter, but it will suffice to note, that in this, the second chapter

of embryonic development, there is a remarkable conformation of
the suspected similarity of the events in the apes and Man.   And
at the same time it is to be remarked that where, as in these
Primates, "inversion" occurs, it follows that the amnion owes its
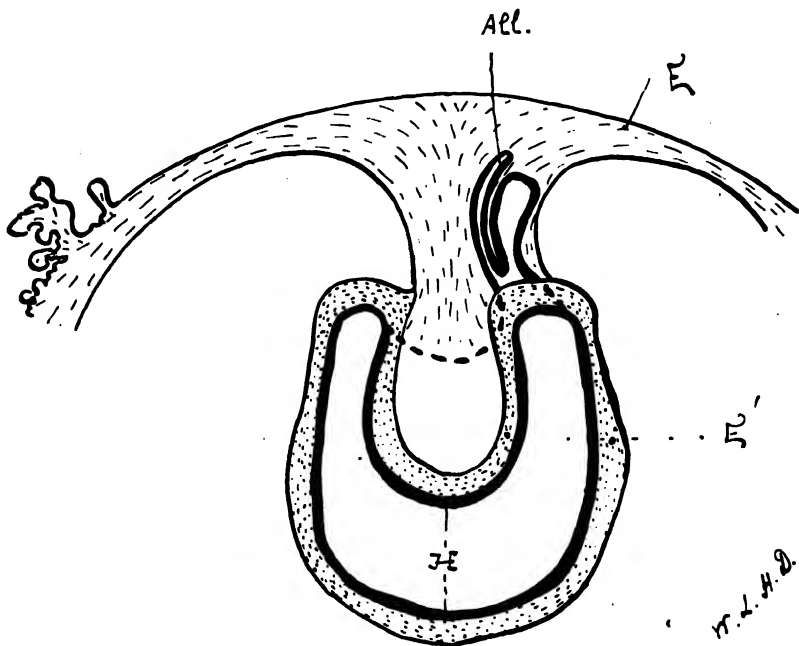
Fig. 145.   Diagram (adapted from Mall's figure) of an early human embryo in
which evidence of inversion of the germinal layers may be found.   *E*. Ectoderm
(chorionic).   *E'*. Ectoderm (non-chorionic).   *H*. Ectoderm.   *All.* Allantoic
diverticulum.

formation to a process essentially different from that obtaining in
most of the other placentalia, a process which however is described
as occurring in the hedgehog and guinea-pig (Hubrecht), besides
the rodents just mentioned, so that in this respect man does not
stand accompanied by the apes and higher monkeys only[1].

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[1] It appears a matter for surprise that so many writers on embryology during
the last fourteen years should have neglected to discuss the application of Hubrecht's
description of the formation of the amnion, and the phenomena of "inversion"
(first described by Selenka in 1883) to the case of Man and his allies.   This is the
more remarkable because we note that as early as 1889 Graf v. Spee suggested the
possibility of inversion occurring in human embryology, and if inversion occurs it

Chapter III. *The Yolk-sac.* We now come to the chapter which deals with the early development of the yolk-sac. The importance attaching to this part of the subject depends upon the fact that in certain mammals the (in mammals fluid, in Sauropsida solid) contents of the yolk-sac provide for the nutrition of the embryo for a very considerable period; this provision is effected, both by direct withdrawal of the contents of the yolk-sac, and also through the agency of the vitelline vessels, which are distributed abundantly over the surface of the yolk-sac. Now as far as can be judged of human ova, the essential mode of formation of the yolk-sac, and its relation as part of the entoderm to the other important layers (mesoderm and ectoderm), follows the general rule for mammals. The characteristic difference is met with in the further development of the sac: in the most primitive mammals the sac forms a complete lining to the whole of the blastodermic
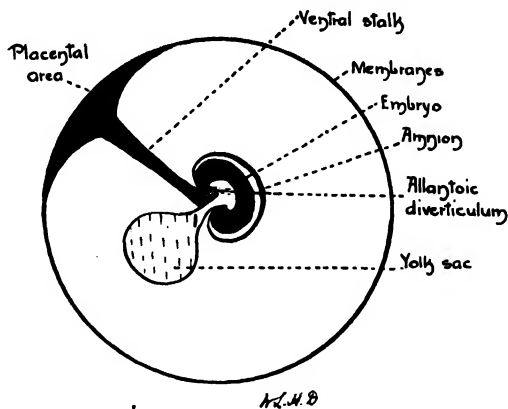
Fig. 146. Diagram of the human embryo and its coverings, to shew the proportionate sizes of the allantois and the yolk-sac. (Cf. Kollmann, *Entw. des Menschen*, Fig. 35, p. 79, and Fig. 104, p. 175.)

follows that the amnion is probably formed, not as usually described by uprising folds which coalesce, but by fission, as described in Hubrecht's account of this structure in Insectivora and certain rodents. But if we consult recent works, we find that while Minot (*Human Embryology*, p. 286) mentions these suggestions, and Parker and Haswell (*Zoology*, Vol. II. p. 550) give a résumé of Hubrecht's work, yet such authors as Marshall, Kollmann, Gilis, and more recently Keith, either entirely pass over in silence the work referred to, or only record the titles of the original papers, without any pronouncement either of acquiescence in, or dissent from the conclusions formed therein.

vesicle: a good example of this may be seen in the young rabbit embryo (cf. Figs. 146 and 147). But in the higher apes and Man, such a development is not seen; at no period, apparently, does the yolk-sac form such a complete lining, and on the contrary it is in relation with the wall of the blastodermic vesicle for a very short period and over a small area of surface only[1].
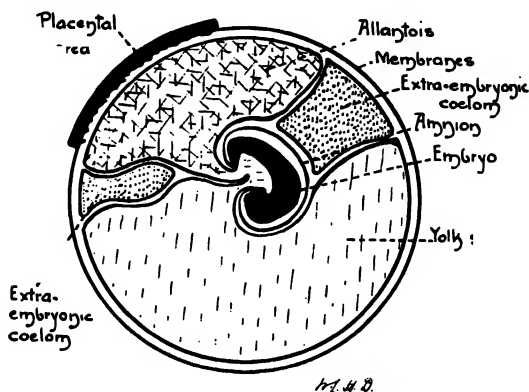
Fig. 147. Diagram of a rabbit embryo and its coverings, for comparison with Fig. 146; to shew the proportionate sizes of the allantois and the yolk-sac. Adapted from van Beneden's figure as modified by Marshall.

The yolk-sac in Man has thus entirely lost the function ascribed to it by Osborn (cf. Kollmann, *Entwick. des Menschen*, p. 169) and others, in Opossums and other marsupials, of coming into contact with the uterine walls, and of producing villi which enter the uterine mucosa, which, being invaded by vitelline capillary vessels, act as the villi of the placenta act in higher mammals. Nor does it appear to be the case that in Man, any more than in certain other higher mammals, the entoderm of the yolk-sac contributes processes which enter a placenta formed on the embryonic side by mesodermal allantois (i.e. an allantois composed of mesoderm

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[1] So far therefore as is known, the human blastodermic vesicle differs from that of the rabbit in the important respect of the conformation of its wall. For from His' description of Reichert's ovum (cf. Marshall, *Vertebrate Embryology*, p. 473) it would appear that in the human blastodermic vesicle the wall consists of ectoderm only, whereas in the rabbit ectoderm and entoderm combine to form the wall. Cf. Figs. 146 and 147. But this difference is not generally insisted upon.

without entoderm) only, so that the entoderm and mesoderm may share in the formation of the placenta even where the allantois provides mesoderm only. (Cf. Hughes, *Brit. Med. Journal,* 1895, p. 1341.)

On the contrary, the human yolk-sac has a most transitory nutritive function, and although still capable of recognition in the placenta at birth, its physiological significance is practically *nil* after the first few days of development[1].

Chapter IV. *Attachment of the ovum.* The fourth chapter of events proposed for consideration deals with the method of attachment of the human ovum to the maternal tissues, and the mode of nutrition of the embryo. In the first place, there is now evidence (Leopold's case quoted by Barlow, *Obst. Trans.* 1898) that the ovum is not, as had been previously suggested, implanted upon a denuded area of the maternal surface (in other words, an area of the uterus denuded of its mucous membrane). The appearances described by Peters in a human ovum (seven days after fertilisation) corroborate this, but as to the details of the process of attachment, no evidence is provided either by this, or by the earliest Hylobates embryo described by Selenka[2].

Secondly (though this is perhaps arguing in a circle), the researches of Selenka on the embryos of the higher Primates shew that, on the contrary, the maternal tissues hypertrophy, the lining (epithelial) cells of the uterus proliferate and produce a syncytium, or mass of rapidly developing cells. It is to be particularly noted that in the lower apes such proliferation and hypertrophy occur on two aspects of the embryo (with the subsequent formation of two placental areas[3]). This occurs as a rare anomaly in Man, and then provides an exception to the rule that but one such area of hypertrophy is to be found; nevertheless it is an anomaly which suggests in the Hominidae a former similarity to the process which has been retained in the Apes. Selenka thus regards the syncytium as derived neither from the chorion-entoderm (Kollmann), nor from the submucous

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[1] Ballantyne seems to dispute this; cf. *Obst. Trans. Edin.* Vol. xxiii.

[2] Cf. Robinson, *J. A. and P.* xxxviii., 1904, p. 490.

[3] See footnote (1) on p. 212.

uterine decidual connective tissue cells (Minot, *Human Embryology*, pp. 13 and 375), nor from the foetal ectoderm (Robinson, *Hunterian Lectures, J. A. and P.* Vol. XXXVIII. p. 493), but from the epithelial lining of the uterus. Into this area of hypertrophied mucous lining of the uterus the ovum enters, and it would seem to be entirely enveloped in the spongy mass. From one pole of the ovum, the ectodermal covering (primitive chorion) is still further projected in tufts into the maternal tissue, and behind and within these ectodermal tufts or villi come masses of mesoderm cells, which are ultimately permeated by blood vessels.

Meanwhile from the portion of the ovum not thus deeply projected into the maternal tissue the embryo has been developing, and in the course of time the connection between the embryo and the projected part of the original blastodermic vesicle is provided by a solid stalk of mesoderm called the Ventral-stalk, or Haft-stiel, which in its solidity and precocity of development is characteristic of the human embryo and the embryos of a few exceptional mammals, including the Primates (Selenka). Turning back to what has been called the " deeply-projected part " of the vesicle, it is found that both this and the adjoining maternal tissue become vascularised to an extraordinary extent (cf. Fig. 148) on the embryonic side by the arrival of vessels diverted from the primitive and transitory yolk-sac system of blood vessels, and on the maternal side from the uterine capillaries. On the maternal side, the capillaries work their way in between the cells of the hypertrophying mucosa, and project in the interstices with a covering of the thinnest description of endothelial cells; these are destroyed, probably by the action of the syncytial cells of the mucosa, and thenceforward the contents of the maternal capillaries bathe the projections or villi of the blastodermic vesicle. These villi themselves being honeycombed with capillary vessels, derived as already stated from the embryo, provide an approximation of the closest nature between the blood of the mother and that of the embryo, the only intervening layers between the two being embryonic in origin, and consisting (theoretically at least) of the remains of the embryonic ectoderm (which practically vanishes) and the endothelial coat of the embryonic capillary. The closeness of this connection, and the degree of the entwinement of the embryonic
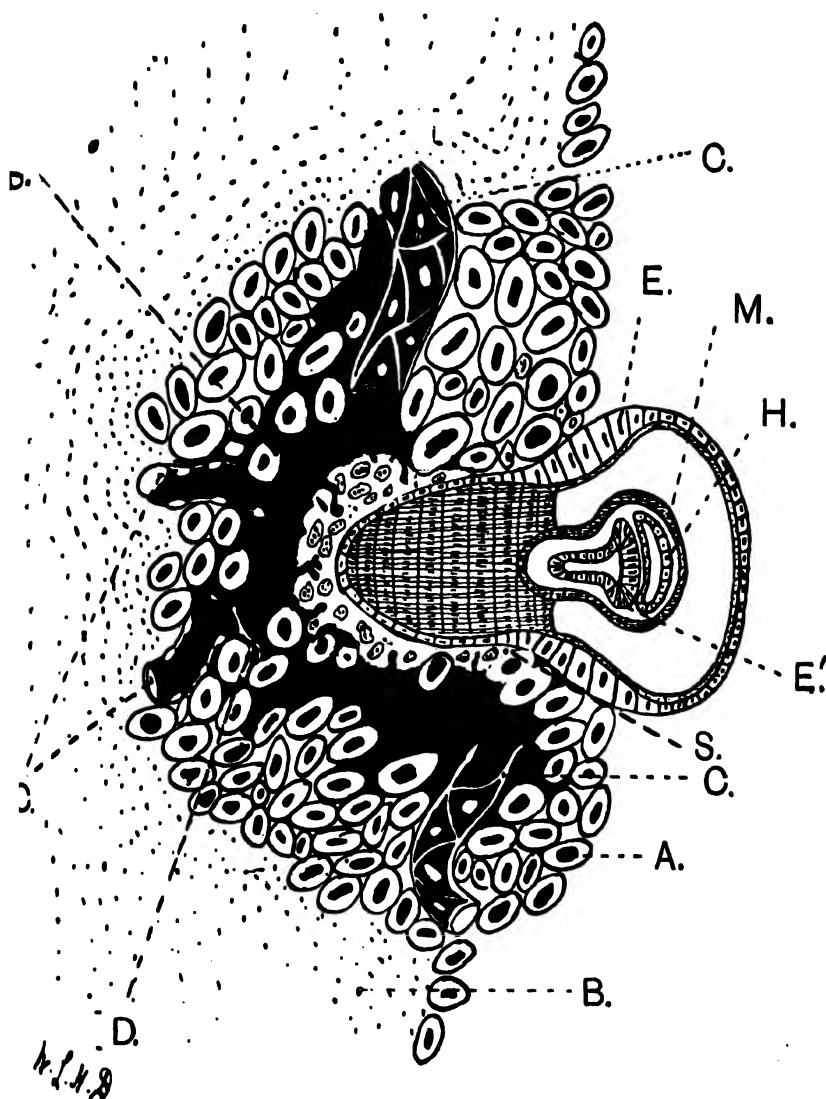
Fig. 148. Diagram of an early embryo of Semnopithecus (Cercopithecidae) (after Selenka), to shew that the "intervillous" space is primarily an intercellular space of the uterine epithelium. *A*. Decidual cells of uterine mucous membrane. *B*. Deeper decidual cells. *C*. Maternal capillary vessels opening into the intervillous spaces. *D*. Remnant of the wall of a maternal capillary vessel. *E*. Foetal ectoderm (chorionic). *E'*. Foetal ectoderm (non-chorionic). *M*. Foetal mesoderm. *H*. Foetal entoderm. *S*. Syncytium.

villi and their capillaries, with the maternal mucosa and its blood-sinuses, constitute peculiarities of the placenta shared by Man and the apes, distinguishing them from other mammals (in which the connection of maternal and embryonic derivative structures is not so close). The two resulting types of placentation are commonly contrasted as the deciduate and non-deciduate varieties[1].

But the nature of the intervening layer of tissue between the maternal and the embryonic blood, and the destructive action of certain cells and their reference to the maternal or to the embryonic organism, have been matters of longstanding discussions, not to say disputes which have only been comparatively recently composed by the brilliant researches of Selenka. Thus Duval described the intervening layer in Rodentia (the rabbit) as consisting of embryonic endothelium (mesoderm) alone, but the preceding statements are the first dealing specifically with Primates.

Marchand (*Anatomische Hefte*, Band XXI. 1903) describes the histology of some early human ova and their uterine surroundings, but does not appear certain (cf. p. 256, *op. cit.*) of the source of the syncytial layer: as regards the general relation of the ovum to the uterine tissues (the implantation or "Einlagerung"), Marchand (*op. cit.* p. 262) points out that the ovum sinks into the uterine decidua basalis; that, like the rodent (guinea-pig) ovum as described by v. Spee, the embryonic tissues act towards the maternal structures much as a malignant neoplasm, reminding one of that variety of growth known to pathologists as Deciduoma malignum.

Robinson (*op. cit.*, cf. p. 201 *supra*), appears to dissent from Selenka's view as to the maternal origin of the syncytium, which he ascribes to the ectoderm of the foetus. For Robinson, the foetal tissues therefore play a more important part in the production of the placenta, of which they form a larger constituent than on Selenka's view. If this is so, opinion as to the nature of the tissues ruptured and separated with the placenta at birth must be modified accordingly, as will be indicated in the appropriate connection (p. 207).

From Selenka's researches (cf. Selenka, *Menschenaffen*, Kapitel III. *Das Ei des Gibbon*, also *Placentaranlage des Lutung*[2], *Biol.*

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[1] *v. infra*, p. 205; and footnote (1), p. 209.

[2] Lutung; the native name for a species of Semnopithecus found in Borneo.

Centralblatt, XVIII. No. 15, with Kollman, *Entw.* p. 164, Fig. 94, and Leopold, *op. cit.*, cf. p. 201 *supra*), it would nevertheless appear that there is the very closest similarity between the process in Man and in the higher Primates.

The Placenta. *Attachment of the ovum, and nutrition of the early embryo (continued).*   In the chapter descriptive of the Order Primates it will be noticed that the placenta is enumerated among the criteria used for distinctive purposes, and indeed to the characters of this organ as a means of classifying the mammals possessing it much importance was at one time attached.   A brief note on this subject may therefore not be out of place in this connection. One of the chief contributions to the comparative anatomy of the placenta was made by Turner, and the classification suggested by him was quoted (as recently as 1900), by Kollmann (*Entw. d. Menschen*).   This classification was as follows :

(1)   Deciduata : characterised by the close connection of the uterine mucous membrane and the placenta foetalis, detachment of both structures occurring in parturition : ex. Man, Apes and probably Lemurs.

(2)   Demi-deciduata : characterised by the less close connection of the above-mentioned structures, and by a partial detachment, at birth : ex. Carnivora, Insectivora, Proboscidea, Cetacea, Edentata (Dasypus and Choloepus among the latter).

(3)   Indeciduata : characterised by an even less close connection ; ex. Ungulata, such as Ruminants, Swine, Horses, Tapirs, and also certain Cetacea : while Marsupialia (Metatheria) and Prototheria were supposed to be implacental.   Diagrams now well-known[1] were published in illustration of the various conditions.

Later research caused a modification of this scheme, for among the Edentata in particular, the latitude of variation in placental structure has thrown doubt on the value of this character as a classificatory criterion.

In 1889 Hubrecht suggested a complete revision of the foregoing classification, and submitted (as specially antagonistic to

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[1] Cf. Foster and Balfour, *Embryology*, Macmillan.

Turner's views of the homologies of the several histological strata involved, and particularly to Turner's suggestion that in the human embryo the arborescent villi are invested by prolongations of the uterine mucous membrane) the following statements:

(1)   That in numerous Orders the epithelium of the uterus entirely disappears over the future area of attachment of the blastocyst. (But from Leopold's researches it seems that this statement does not apply to the human embryo, W.L.H.D.)

(2)   That in some (the more primitive) of these Orders, the lacunary blood-spaces are in contact with the blastocyst before the appearance of the embryonic area vasculosa.   Hubrecht suggested later that the embryonic epiblast causes absorption of these maternal tissues (*Proc. Internat. Zool. Congress*, 1898).

(3)   That the communication between the lacunae and the maternal vessels is not a mere dilatation of capillary vessels as described by Turner, but a more complicated process.

(4)   That embryonic epiblastic tissue (termed trophoblast) appears between the villi of the blastocyst and the maternal blood. Later (in 1898, *op. cit.*), Hubrecht urged that maternal blood enters into clefts in the trophoblast, and that, subsequently, embryonic villi are introduced into these blood-filled clefts, pushing a layer of trophoblastic epiblast before them.

An essential point in Hubrecht's work is the indication that before the establishment of the ordinary placenta the embryo may receive nutriment from the maternal blood, which enters and circulates in the clefts or lacunae in the embryonic trophoblast.

It would thus appear that as far as the human embryo is concerned, Hubrecht is inclined to derive the placental tissues more largely from the embryonic side than from the maternal mucous membrane, and with regard to this (and particularly to the syncytial cells), it is to be noted that Turner's view rather than Hubrecht's is supported by the latest observations of Selenka on the Semnopithecus pruinosus, observations which are almost certainly applicable to the human embryo[1].

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[1] Hubrecht also pointed out that among the Primates, the Lemuroidea are non-deciduate, with the remarkable exception of Tarsius, an animal already in a somewhat exceptional position as judged by morphology, and which thus finds

Robinson (*op. cit.* cf. p. 201 *supra*) would presumably support Hubrecht's view. But if the placenta is so largely foetal, it becomes doubtful whether any maternal tissues are ruptured or detached when the placenta is separated from the uterus. In fact Robinson suggests that foetal tissue may even remain in utero, there to be subsequently absorbed. But with this view, the application of the term "deciduate" to these placentae (of the Hominidae and Simiidae) falls to the ground, for we have just seen that detachment of maternal tissue is a necessary qualification by reason of the terms of definition laid down. Indeed a revision of the classification of placental types was seen to be necessary by Strahl; Robinson however rejects Strahl's amended classification, and has submitted another amendment, with which his name may be associated, and which is appended. (Cf. p. 210, footnote 1.)

Mode of nutrition. The enquiry into the mode of the earliest nutrition of the embryo has received a considerable amount of attention. Selenka shewed twenty years ago that secretions of the uterine glands apparently nourish the ovum of the Metatheria (Marsupials); in Rodentia, Insectivora and Cheiroptera this is less likely to be the case, since the uterine glands early vanish; in Carnivora and Primates, it is suggested that nutriment is derived from the uterine lining in this way, but exact information seems to be lacking, and against this view it may be urged (in spite of Minot's statements, *op. cit.*, p. 375) that hypertrophy (not absorption) seems to be the characteristic of the uterine epithelium. Hubrecht has suggested another method whereby the early embryo may derive nourishment (cf. the preceding paragraph), and Ballantyne (*Obstetrical Transactions, Edin.*, Vol. XXIII.) urges that the vitelline circulation may also play a part, in addition to possessing the

itself associated with the Anthropoidea, and accordingly among the Deciduata. On these grounds Hubrecht has attempted to separate Tarsius entirely from the Lemuroidea, but recent criticism by Dr Elliott Smith, *Proc. Linn. Soc.* 1903, shews that this attempt cannot be regarded as successful.

Subsequently, Hubrecht proceeded to shew evidence of blood-formation in the placenta of Tarsius, and to urge that there may be an actual and absolute communication between the circulatory systems of the maternal and embryonic organisms. A final pronouncement on this question seems to be still in abeyance, but its importance as occurring in a placenta so like that of the Hominidae cannot be ignored.

ordinary functions attributed to it. The characters of sympodial human monsters, in which allantoic and therefore "umbilical," as contrasted with "vitelline," vessels are conspicuously absent, are urged in support of the latter view, as are also cases of Exomphalos, and observations on Rodentia, Cheiroptera, and Insectivora. Minot does not support Ballantyne, and the question of a primitive vitelline placental circulation must be left undecided.

It remains to notice the later character of the placenta, and its specific features in the Primates. In the higher members of the Order including the Hominidae, the placenta is disc-like in form, and is termed metadiscoidal (Figs. 149 and 150). In the Lemuroidea (except Tarsius and perhaps Daubentonia), the placenta is diffuse; into the differences between the two varieties it is not necessary to enter in detail, but it may be remarked that the chorionic villi in the Anthropoidea persist only in the limited area corresponding to the eventual placental disc, whereas in the

Fig. 149. Foetus of Hylobates mülleri, about 57mm. in length; the discoid placenta is shewn. (Specimen, Hose donation, III. Mus. Anat. Cant.)

Lemuroidea the villi remain and develop on the whole periphery of the embryo. Accompanying these differences between the Anthropoidea and Lemuroidea are others chiefly dependent upon the development of the allantois.
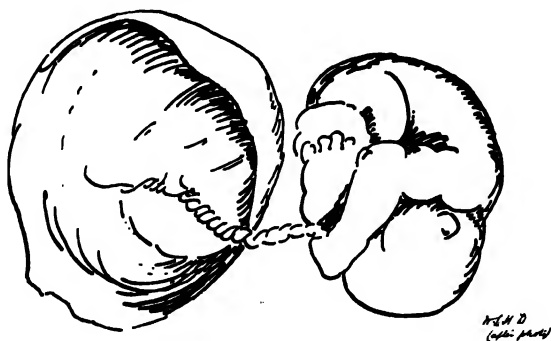
Fig. 150. Foetus of an Orang-utan, with discoid placenta. (After Strahl.)

The anthropoid placenta has been termed metadiscoidal in distinction from the discoidal placenta found in certain rodents (especially the rabbit). The distinction is stated (Foster and Balfour, *Embryology*, p. 358) to depend on the fact that in the human embryo the allantois spreads over the whole inner surface of the sub-zonal membrane, whereas the allantois is of limited extent in the rabbit. Now there are two objections to this statement. In the first place, the subzonal membrane is defined by Foster and Balfour (p. 346, *op. cit.*), following Turner, as a compound of the false-amnion and the wall (entoderm) of the yolk-sac; but we are given to understand (cf. His' interpretation of Reichert's ovum, and Marshall's comments, *Vertebrate Embryology*, p. 476), that the latter is a comparatively insignificant structure in the human embryo; that it does not extend far in the direction of the wall of the blastodermic vesicle; and certainly is not comparable in this respect to the yolk-sac of the rabbit. (Cf. Figs. 146 and 147.)

Secondly, so far from the allantois extending over the whole of the inner surface of the sub-zonal membrane, or wall of the blastodermic vesicle in Man, we are now given to understand that the allantois of the higher Primates is a very insignificant structure when compared with that of such a form as the rabbit.

For these reasons it is impossible to distinguish the discoidal and metadiscoidal placentae in the way suggested by Foster and Balfour, and it is suggestive to notice that the distinctions are not insisted upon by later writers. Of these, Minot suggests a more intelligible classification of placentae into, (1) true chorionic, and (2) allantoic varieties (*Human Embryology*, p. 376). In the former, the chorion receives the blood vessels from the embryo by way of the allantoic stalk, which may be a solid mass for the greater part of its length (Haft-stiel); in the latter, the allantois grows rapidly, its cavity enlarges, it becomes vesicular and covered with blood vessels; its enlargement brings it into contact with the chorion, and when the wall of the allantois touches the chorion, blood vessels begin to pass from the former to the latter layer. The higher Primates (and Tarsius) are found to be associated with the unguiculate Eutheria in the first of these classes, while the lower Primates (the Lemuroidea, except Tarsius) fall, with the Ungulata

and the other Eutheria, into the second group[1]. In this respect, then, Man and the Anthropoidea are, as before, closely associated; it only remains to mention here that the recent researches of Strahl (Selenka's *Studien*, Heft XII. 1903), on the histology of the fully-formed placenta of the Orang-utan reveals a practical identity of structure with the corresponding human organ[2].

We have thus considered the elementary conditions of the ovum,

[1] It has already been remarked that a complete revision of the classification of placentae is necessitated by the acceptance of the views of Hubrecht and Robinson on placental structure. Robinson has proposed the following classification (*op. cit.* p. 500, *ibid.*).

Placental varieties:

(A) Placentae appositae: no rupture, but simply separation occurs at birth.

(B) Placentae conjunctae: in which maternal and foetal tissues are closely conjoined.

Both divisions are again sub-divisible, Group (A) including the varieties known as (*a*) diffuse, (*b*) cotyledonary, and (*c*) some forms of zonary placentae. Group (B) includes other forms of zonary placentae, and the discoidal form shared by Man, the Apes, and certain other Eutheria.

[2] Strahl's researches on early Orang-utan embryos (*Anat. Anz.* 1902, p. 173). The author has examined Selenka's material, viz. five pregnant uteri of Simia satyrus.

The youngest embryo would correspond to human embryos of about two weeks, and is in general appearance very similar to these, but two striking differences were noticed:

(*a*) The blastodermic vesicle is larger, the villi are stouter and more stunted than in Man, and also less thickly aggregated: in each case the typical human cell-layer and syncytial-layer were observed. Extension of an ectodermic covering to the villi was not observed.

(*b*) The structure of the uterine wall is distinctive, particularly that of the basalis-layer. Strahl says that the "basalisleisten" (corresponding to the septa placentae of Man, in whom the septa are much less regularly arranged than in the Orang-utan, where they are radial), and the (radial) arrangement of the enlarged uterine glands, constitute diagnostic peculiarities distinguishing the Orang-embryo from that of Man at the corresponding stage. The older uteri confirm these observations, otherwise there is a close similarity to the human condition. Langhan's fibrin-layer could not be seen. More detailed accounts are given by Strahl in the latest volume of the series commenced by Selenka, dealing with the embryology of the higher Primates. A *résumé* of this was given at the Heidelberg Meeting of the German Anatomical Society in 1903. In the larger monograph, Strahl states that the placenta of the Orang-utan approaches that of Man more nearly than that of the Gibbon. Otherwise a general similarity in respect of the forms of the gravid uterus and placenta in its later stages, obtains between the three types. The chief differences are microscopic, and consist in the conformation of the uterine decidual tissues. In Man, the syncytium is more extensive than in the Simiidae.

the mode of its attachment to the maternal tissues, and the method of its nutrition. For the establishment of the close connection between the circulations of embryo and parent is followed by the exchange of nutritive material and products of metabolism which fulfil the necessary conditions for progressive development. And because the processes in other animals are so fully and clearly described in the text-books, we have here dwelt upon only such points as are of importance in the particular case of Primate development. Up to this point we have seen that while, in general, the human ovum goes through a series of phases which find their counterpart in most mammals (some of them being common to all vertebrates), yet the closest resemblances are with the apes[1].

We may further note that since the Primates present such very distinct characteristics of development, it is not correct to describe their embryology, as is so often the case, without clearly distinguishing it from that of other mammals. Again, we should notice that of the peculiarities observed, it happens that in several instances the characteristic feature is precocity of the formation and appearance of certain structures, which are acquired more slowly by other mammals. And the explanation offered for this characteristic precocity seems a valid one, viz. that where so high a specialisation in certain respects has to be attained, there will

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[1] One of the most recent reviews of the subject comes from the late Professor Selenka (*Centralblatt für Biologie*, 1901), who points out the following close resemblances between the developing embryos of the Hominidae, of the Cercopithecidae, and Simiidae:

    (1) Precocious concrescence of the blastoderm with the newly formed uterine mucous membrane. .

    (2) Precocity of development of the chorionic villi.

    (3) Precocity of development of the mesodermic tissues.

    (4) Precocity of development of the closed amnion.

    (5) Precocity of development of the vitelline vessels.

    (6) Tardy differentiation of the embryonic area.

    (7) Reduction of the allantois to a short hollow cylinder.

    (8) Pronounced retroversion of the vertebral column up to the 6th week.

    (9) Modification of the allantoic stalk into a stout shaft of support.

    (10) Attachment of the stalk of the yolk-sac to the shaft so formed (9).

On the other hand, cerebral differentiation makes its appearance as early as the sixth to seventh week of development, and it is on considerations of the appearance of the brain that reliance must be placed in distinguishing the human embryo at this stage.

of necessity be a tendency to abbreviation of the earlier phases, which are more protracted in such forms as have not to travel the same distance beyond those early stages. The very early formation of the amnion, the precocious appearance of the allantois, the early formation and transitory functional period of the yolk-sac are thus explained as abbreviations of the recapitulated history. But while we find the closest approximation between Man and the Anthropoidea, in respect of early embryology, the chief evidence in those portions of the history thus studied, of the close association between Man and the Simiidae, is that discovered by Strahl in the characters of the histological structure of the placenta. (Cf. p. 210, footnote.)

With regard to this part of the subject, the disc-like character of the external form of the placenta has already been mentioned (cf. Figs. 149 and 150, p. 208): in the Simiidae the disc is, normally, single as in Man. Among the Cercopithecidae, as has been already mentioned, two discs are normally formed (this occurs as an abnormality in the Hominidae, *v. supra*, p. 201), and both provide the foetus with nourishment. Pregnant uteri of Cercopithecidae, with the fully formed placenta *in situ*, have been described by Selenka[1] (*Beiträge zur Entwick.*), Kollmann (*Anat. Anzeiger*, 1900), and Keith (*Proc. Anat. Soc.*, May 1900, p. xlvi): the latter observer remarks that the appearance of the two placentae suggests their derivation from a zonary placenta, and the inference is submitted, that the ancestral forms of the Cercopithecidae possessed the latter type of placenta. Keith further recalls the fact that the Cebidae on the other hand are characterised by a single disc-like placenta. We thus find the Hominidae, Simiidae, and Cebidae allied, while differing from the Cercopithecidae in respect of the external form of the placenta.

Other evidence we shall find, if we pass to the consideration of a stage in embryonic development intermediate between those just studied and the earlier of those (viz. 4—5 months) investigated in the previous chapter. In the first place we may notice the very

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[1] The description of twin placental discs in Hylobates is ascribed by Kollmann to Owen. Selenka also described the placentation of Hylobates as bi-discoidal, but wider research led him to the conclusion that this is anomalous, a single disc occurring normally in the Hylobatidae (cf. Strahl in Selenka's *Beiträge*, Heft xII., p. 421).

peculiar dorsal flexure seen in the embryos of the Hominidae and
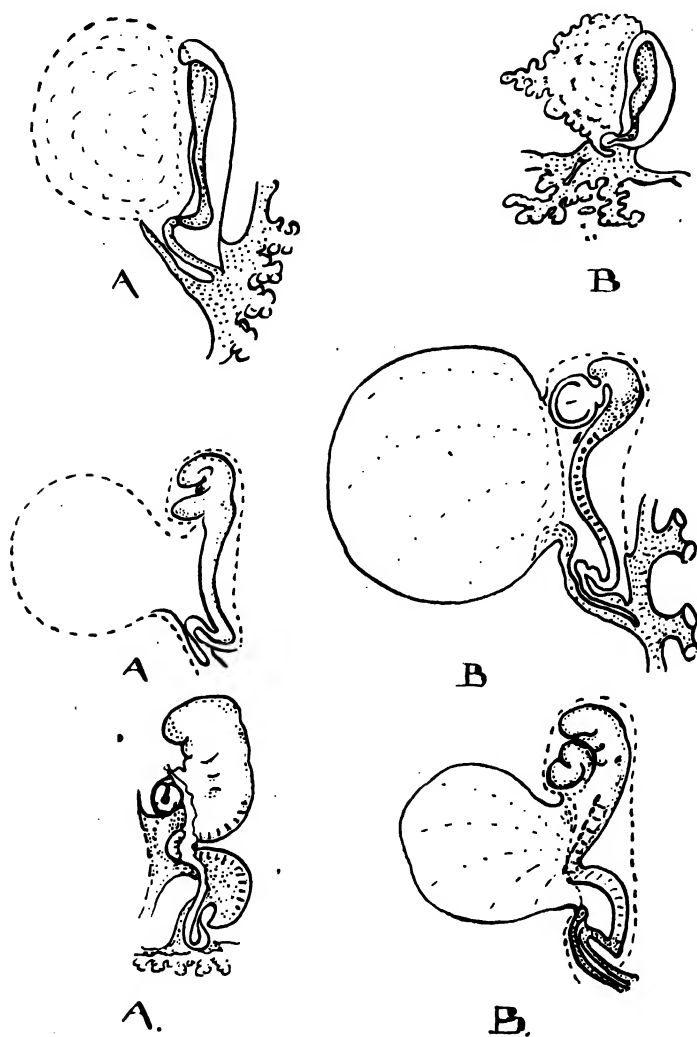
Figs. 151, 152, 153.

Fig. 151.   (A) Human embryo; (B) Embryo of Hylobates rafflesii.
Fig. 152.   (A) Human embryo; (B) Embryo of Semnopithecus cephalopterus.
Fig. 153.   (A) Human embryo; (B) Embryo of Macacus cynomolgus.

the higher Primates, at the 3rd week; it is considered by Minot to be characteristic and distinctive of these.

Secondly, we may with the aid of Selenka's illustrations in the memoir just quoted (*Centralblatt für Biologie*, 1901), trace the close similarity that obtains between the embryos of Cercopithecidae and Hominidae in general appearance, and at the same
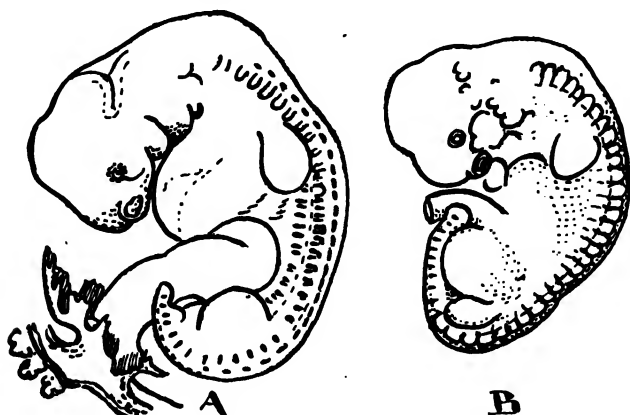
W.L.H.D. (after Selenka).

Fig. 154. (A) Human embryo; (B) Embryo of Semnopithecus mitratus.
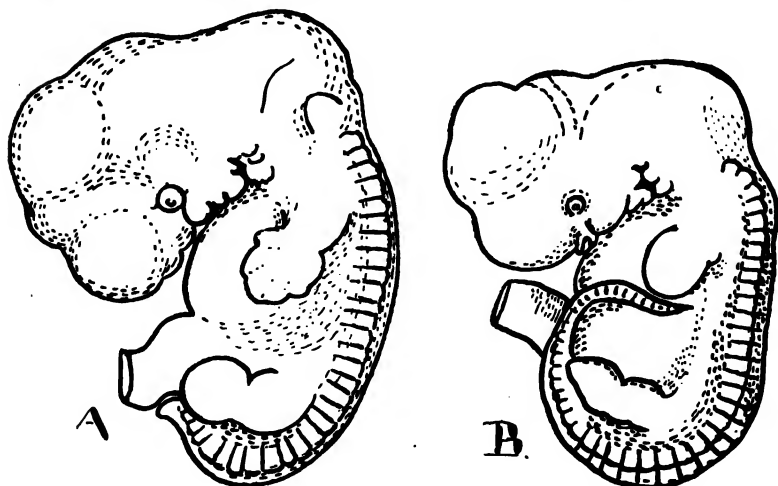
W.L.H.D. (after Selenka).

Fig. 155. (A) Human embryo; (B) Embryo of Macacus cynomolgus.

time note how marked a difference is produced by the elongation of
the tail in the former even at an early period. (Cf. Figs. 151—156).

The human embryo at successive stages from about the twelfth
day to about the forty-second day is indicated in these figures by
the letter (A), and compared with embryos of apes of corresponding
ages. The illustrations are slightly modified from those published
by Selenka.
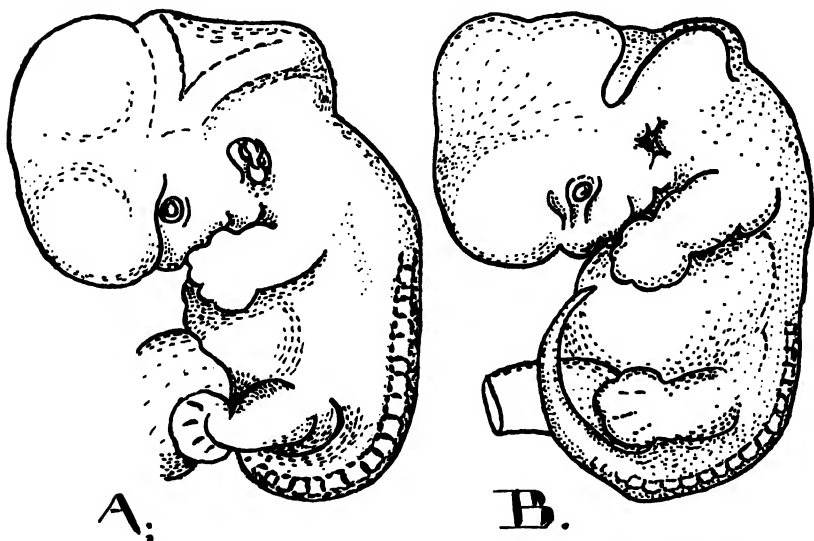
W. L. H. D. (after Selenka).

Fig. 156. (A) Human embryo; (B) Embryo of Macacus cynomolgus.

Finally, when we compare the human embryo of about the
sixth week with the simian embryo figured by Selenka (*Beiträge
zur Entw.*, Heft VII., p. 167, cf. Fig. 157), we note a very re-
markable similarity, most evident perhaps in the facial develop-
ment, and in the lack of prominence of the caudal vertebrae,
whose elongation even at this early stage characterises the embryos
of the lower Anthropoidea. It has not been demonstrated that
the tail of the human embryo at this stage contains any greater
number of caudal vertebrae than those which ultimately form the
coccyx[1].

On the whole question then of the evidence to be drawn from
Embryology, we find that of Comparative Anatomy corroborated;

[1] Cf. Waldeyer, *Sitz. der. kais. preuss. Akad.* 1896.

we conclude that this evidence associates Man, firstly with the
Primates, and within that Order, in turn with the Anthropoidea
and the Simiidae.   With the embryology of the members of the
latter family (Simiidae), the development of the human embryo
runs parallel for so long a period, that the conclusion is confirmed,
which claims that the Simiidae reproduce in many, if not all, respects,
a definite and comparatively recent phase in the history of Human
Evolution.
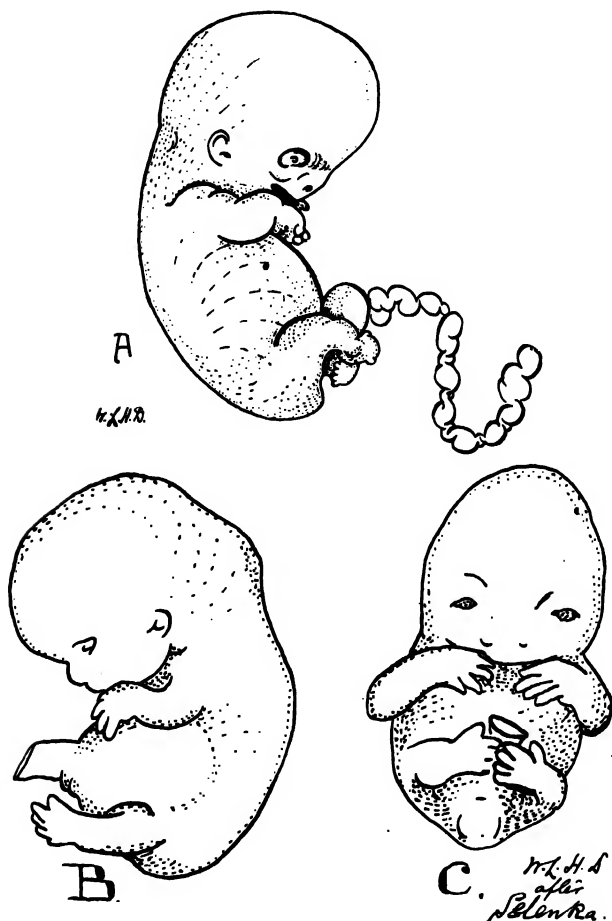
Fig. 157.   A. Human embryo.   B. Embryo of Hylobates mülleri
at an age corresponding to that of the human embryo represented in A.
C. Another aspect of the embryo Hylobates represented in B.

SECTION C.

VARIATION IN ANATOMICAL CONFORMATION.

CHAPTER IX.

ANATOMICAL VARIATIONS.

FOLLOWING the evidence provided by Embryology, will be taken that derived from the study of anatomical variations. The investigation of variations has long attracted the attention of biologists, and the recent advances, particularly in the statistical treatment of data are extraordinarily great. While the lower forms of animal life lend themselves more profitably to investigation than the higher, yet even in the latter research has not been barren. Of those who are foremost in this field, Bateson, Pearson, and Weldon in this country, and Davenport in America must be specially mentioned. In regard to the particular department with which we are now concerned, the chief contributions have been made by Testut[1], Le Double[2], Kohlbrügge[3], Dwight[4], Macalister[5], Cunningham[6], and Huntington[7], while at an earlier date, Stieda[8] published a treatise on the application of the theory

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[1] Testut, *Les variations musculaires de l'homme expliquées par l'anatomie comparée.*

[2] Le Double, *Traité des anomalies musculaires de l'homme*; also *Traité des anomalies des os du crane.*

[3] Kohlbrügge, *Atavismus*, Utrecht, 1898.

[4] Dwight, *Anatomischer Anzeiger*, Band xix.

[5] Macalister, *Boyle Lecture*, Oxford, 1894.

[6] Cunningham, *J. A. and P.* Vol. xxxiii.

[7] Huntington, *American Journal of Anatomy*, Vol. ii., 1902–03, p. 157.

[8] Stieda, *Archiv für Anthropologie*, Band xiv.

of probability to the treatment of anthropological data, of which the full value has only comparatively recently been realized.

Macalister's *Boyle Lecture* is so important that a few notes as to its purport must be added in the present place. The author points out that the extensive study of anatomical variations leads to the formulation of at least four generalised propositions, to the following effect:—

(1) Organs which in the human body are least subject to variations are, in the animal series also, the most constant and uniform as regards their characters: and conversely, organs which in the vertebrate series exhibit very diverse forms in different groups of animals, present in the human body a high degree of variability both in point of frequency and also of range or extent. The mesencephalon may be cited in illustration of the former, and the caecum, of the latter statement.

(2) Organs which have had a simple (ontogenetic) developmental history are more stable than those whose formation is the result of more complex processes.

(3) Of such parts as are repeated in series (such as teeth, ribs, or vertebrae), the terminal members of the series are more variable than the medial.

(4) Those parts are least variable which are the most uniform and constant in their function; and those are most variable which present the greater range of function, or whose action is limited by any conditions.

The foregoing generalisations are designated by the author, (1) the ontological, (2) the embryological, (3) the homological, and (4) the teleological propositions.

Secondly, Macalister insists on the desirability of a natural classification of variations, and proposes the following categories, viz.: anomalies of (1) quantity, (2) material, (3) repetition, (4) cohesion, (5) alternation, (6) position, (7) series, (8) inheritance, (9) new formation: examples of the several classes are given and their significance is fully discussed[1].

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[1] It will be noticed that no special class is set apart for anomalies commonly recognised as pathological deformities. As a matter of fact such pathological variations, if their nature is investigated, will fall within one or other of the above divisions.

Finally, the questions of (*a*) the direction or trend of variation, and (*b*) the continuity or discontinuity of variation are discussed.

Huntington (*op. cit.*, cf. p. 217 *supra*) has proposed a classification of muscular variations under the headings of (1) Fortuitous, (2) Progressive, (3) Reversional variations, and has ingeniously illustrated the third group with reference to the modifications presented by the pectoral group of muscles in the Primates.

The application and significance of the study of variation in the present connection is closely bound up with the study of variations of the eighth class proposed by Macalister (Huntington's third group), i.e. variations of inheritance, or atavisms, the interest of this branch of investigation depending on the consideration that among the recorded departures from what may be regarded as the normal (in other words the most frequent) conformation, certain instances occur of the reproduction of characters constantly found in other mammalian groups. Such occurrences, it has been suggested, should be explained on the hypothesis that reversion to an ancestral phase of evolution has here taken place ; and from this it is argued that the abnormality is indicative of a stage through which the ancestors of the individual passed in their evolutionary progress. Like the pineal body, the thymus gland, or the embryonic branchial clefts[1], such variations are to be interpreted as " histogenetic memories " (to quote again Professor Macalister) of the features of ancestors of whose existence no trace would otherwise remain. We have spoken above of " certain instances " and the qualifying adjective is used advisedly in view of the fact that while, as explained in the preceding paragraph, some anatomists have regarded all or almost all variations as endowed with a reversive or atavistic significance, others are disposed to deny to them any such value. As an exponent of the " atavistic " school, the name of Testut may be mentioned[2]. Diametrically opposed to the adherents to this view is Kohlbrügge.

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[1] A long list of anomalies considered by the author to fall within this class was published by Raphael Blanchard, *Revue d'Anthropologie*, 1885, p. 425.

[2] Although in the *Boyle Lecture* Macalister couples the name of Le Double with that of Testut as referring all anomalies to atavism, it may be noted that Le Double in his work on *Muscular Anomalies*, Vol. II., p. 459, demurs to this ; for, as he explains, he adopts at least a threefold classification.

Between these extremists will be found authors who, like Macalister, prefer to steer a middle course, as safest in view of the limitations of actual knowledge. For those who reject "atavism," the difficulty arises of explaining the undoubted occurrences of the abnormal reproduction in one animal, of a structure normally found in a second form (otherwise morphologically distinct), or of an abnormal type of conformation, which corresponds to the type which is normally presented by a second form. The problem is further complicated in many cases by the fact that the embryonic history fails to provide any confirmatory evidence. It is, however, important to note that Huntington makes the following pregnant statement: " ... under adequate physiological stimulus an organ may even be evolved *de novo*, along the same paths and following the same developmental lines which far back in the phylogenetic history of the species led to the production of its prototype, which has in the course of the intervening evolutionary period become rudimentary or adapted to other functional purposes." If admitted, the above possibility seems to render extraordinarily difficult the establishment of the claim to base phylogenetic affinity on the evidence of a given muscular anomaly.

Kohlbrügge regards all or almost all (for he makes the axillary muscle almost the only exception) these occurrences as accidents, explicable on mechanical ontogenetic grounds as yet but imperfectly surmised.

Were Kohlbrügge's views to receive universal assent, such evidence of the descent of the Hominidae as might be forthcoming on the hypothesis of the atavistic significance of variations would fall to the ground; and in anticipation of such a contingency, this line of investigation might well be ignored in the present connection.

But it cannot be said that such universal consent has as yet been accorded to Kohlbrügge's expression of opinion, and moreover that author admittedly makes an exception to the general statement. Until, therefore, a definite theory based upon considerations of the action of mechanical forces in influencing embryonic development shall have been evolved, it seems justifiable to review this part of the subject, even though such a review be somewhat superficial.

Two slightly different lines of enquiry should here be distinguished. In the first place, the foregoing statements refer in the main to variations at the extremes of oscillation from the normal form, though linked to it by numerous intermediate and less aberrant instances. Such extreme cases, when investigated statistically, provide percentages too feeble numerically to render instructive any comparisons instituted between forms in which the normal types of conformation are not otherwise strongly contrasted. The objections that may be raised to the interpretation of such striking abnormalities will be diminished in the case of the less startling divergencies, but the statistical study of the latter in two groups of animals may also be productive of interesting results. It follows therefore that in entering upon the study of variation as elucidative of the relations of the Hominidae, we ought to differentiate the cases of the very aberrant from the less divergent types of anomalies.

In the second place, we must limit the range of comparison, and clearly define the field into which our investigations shall carry us. In accordance with the scheme laid down in Chapter I. the comparison will here be limited for all practical purposes to the Primates, and it would be manifestly irrelevant therefore to deal seriously with such anomalous conditions as for instance hare-lip, divided parietal bone, the musculus sternalis, congenital defect of the radius, or of the corpus callosum, within such limits. Numerous anomalies occur in Man which can only be paralleled in comparatively lowly mammals, or even only in lower vertebrata, such as reptiles or fishes[1]. But although, through limitations of space, such wide considerations must be passed by with a simple mention, it is important to reiterate that in the sum total of their variations, the Hominidae are more closely allied to the Primates than to any other Eutherian group. This demonstration has in some degree been provided in the first six chapters of this book.

And yet again, within this range, we shall find it necessary to further subdivide the work: for we have first of all to enquire whether the variations from the normal structure constitute bonds of affinity between the Hominidæ and the higher Anthropoidea;

[1] An excellent introduction to this aspect of the case is provided in Wiedersheim's *Structure of Man.*

and in the second place to institute a comparison of the variations within the limits of the Hominidae, with a view to distinguishing morphological types within that family: and should the latter expectation be realised, an attempt must finally be made to determine which, if any, of the types thus distinguished stands in the nearest relation to the lower Primates.

We may therefore in the first place review some of the human anomalies or variations which are found normally in one or other of the Primates, after which the subject of the enquiry will be the Hominidae themselves. Our examples of such reversive anomalies are best exhibited in a tabular form, with references to the lists of characters already provided in Chapter IV. (*q.v.*). We there saw that in reference to the anatomy of normal examples of the Lemuroidea the following conditions, which may anomalously obtain in the Hominidae, are of interest.

1. Extensive lacrymal bone.
2. Post-glenoid foramen.
3. Imperfect post-orbital wall. (Cf. Fig. 158.)
4. Entepicondylar (supracondyloid) foramen.
5. Twofold layer of cervical cutaneous muscles.
6. M. dorsi-epitrochlearis.
7. Extensive M. coraco-brachialis.
8. Bicornuate uterus.

While in comparison with the normal anatomical conformation of the Anthropoidea, the following conditions are noteworthy:

9. Fronto-maxillary suture on the inner orbital wall. (Cf. Fig. 159.)
10. Fronto-squamous articulation, instead of a parieto-sphenoid articulation on the side of the skull. (Cf. Fig. 159.)
11. Additional rib-bearing vertebrae, especially in the lumbar region.
12. The following muscles: M. omo-cervicalis, M. dorso-humeralis, M. occipito-scapularis.
13. Absence of a vermiform appendix caeci.
14. Caudate lobe of liver.
15. Lobus azygos impar.
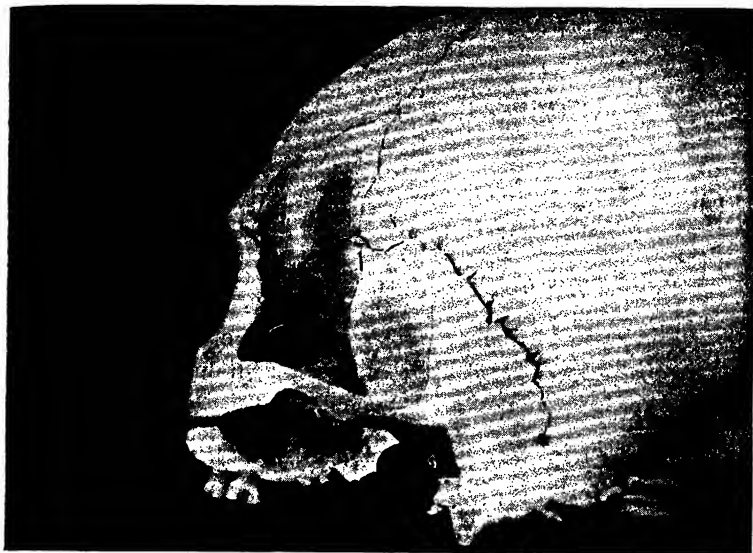
Fig. 158.   Imperfect post-orbital wall : the spheno-maxillary fissure being abnormally wide : cranium of Australian aboriginal.   (Mus. Anat. Cant. W.L.H.D. photo.)

Fig. 159.   Fronto-squamous articulation in the temporal region, and fronto-maxillary articulation on the inner orbital wall of the skull of an aboriginal native of Australia.   Cf. Figs. 21 and 33.   (Mus. Anat. Cant. W.L.H.D. photo.)

With special reference to the Simiidae the following characters are to be noted:

16. Non-bifid cervical spinous processes.

17. A pre-sternal and meso-sternal articulation persisting at the level of the third costal cartilage. (Cf. Fig. 162.)

18. Perforation of the olecranon fossa huméri.

19. Independence of the M. ischio-condylaris (adductor mass).

20. Variable origin of the M. soleus.

21. Disposition of the M. interossei pedis.

22. The formula for the great arterial vessels arising from the aortic arch. The formula $3 + 1$, viz., a common origin for the right subclavian, right and left common carotid arteries with independence of the left subclavian arteries is found in many of the lower Primates. (Cf. Keith, *J. A. and P.*, Vol. XXX. and Parsons. *J. A. and P.*, Vol. XXXVI.)

23. The arteria saphena longa.
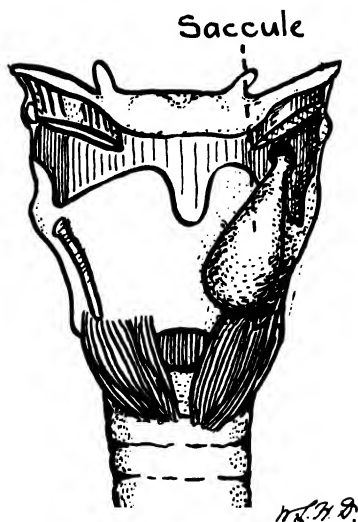
Fig. 160.   Fig. 161.

Fig. 160. Dilated laryngeal sacculus (from a specimen in the Anatomy School at Athens).
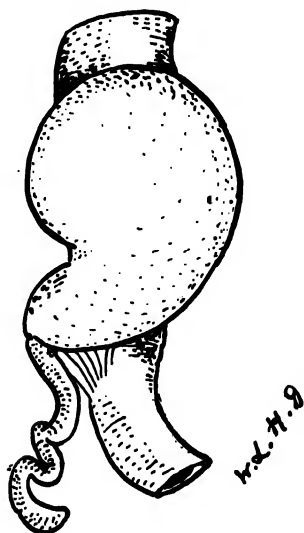
Fig. 161. Simian type of the appendix caeci in a human infant.

24. Dilated laryngeal saccules. (Cf. Fig. 160.)

25. The " simian " type of appendix caeci. (Cf. Fig. 161.)
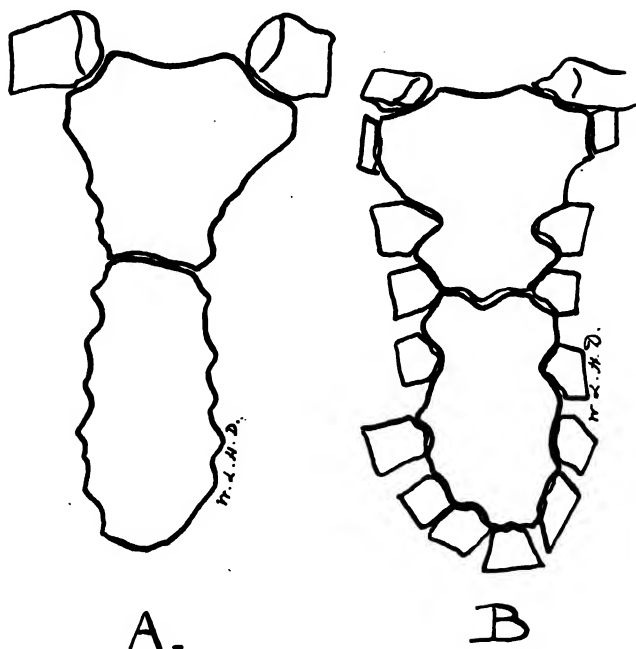
Fig. 162. (A) Human sternum (of an Australian aboriginal) resembling the sternum of a Gorilla (B), inasmuch as the pre-meso-sternal articulation is opposite the third, instead of the second costal cartilage. (Mus. Anat. Cant. W.L.H.D. photo.)

With the foregoing list of illustrations, our consideration of the first part of the subject of anatomical variations must terminate, giving place to the more detailed comparison (*inter se*) of the various morphological types of the Hominidae. Incidentally, however, it may be necessary to recur to the consideration of some of the anomalies of conformation which have found a place in the above selection. This detailed comparison will form the subject of the next six chapters.

CHAPTER X.

COMPARATIVE CRANIOLOGY AND CRANIOMETRY.

AN appeal was made (in Chapter VIII.) to the embryological history of Man, in the search for evidence indicative of the precise path traversed by his ancestors in their evolutionary progress towards the actual human stage. And from embryology the evidence forthcoming, while it indicates that what may be termed an ape-stage marks an epoch in that progress, has not yet provided more exact details than such, for example, as suggest that the history runs for a longer period with that of the Simiidae than of the Cercopithecidae. But no single example among the larger Simiidae can be pointed out with confidence, as embodying the characters of the human ancestor at the simian stage of evolution more completely than any other, though there is a slight margin of evidence in favour of the Chimpanzee, rather than the Gorilla or the Orang-utan. We must therefore acquiesce for the time in what is admittedly a somewhat disappointing result, and await the acquisition of more delicate means of analysis and observation applicable to embryological study. Of the other remaining lines of investigation, that which treats of anatomical variations and departures from the modal type was shewn to be appropriately divisible into two sections. The first of these indicated very briefly the general evidence for the occurrence in human morphology of variations to which an atavistic significance may reasonably be attached. There remains for consideration the second section, viz. that which relates to the comparison of the human races, with the object of ascertaining whether simian characters

are present in any particular race more numerously or in a higher degree than another. Thus we are concerned with studies, which may be collectively designated of the comparative morphology of the human races.

These studies consist in the examination of the varieties of mankind, and of their relations one with another. For present purposes indeed, the field in which evolution is supposed to have occurred must be here regarded as circumscribed within narrow bounds.

Hitherto we have considered mankind as uniform in morphological characters, and this uniform type has been compared with several other Eutherian types. Henceforth we are to take account of the differences existing within the limits of the family Hominidae, and to enquire whether any evidence (and if any of what nature) is forthcoming as to morphological evolution within those limits: to compare or contrast the white man with the negro, with the yellow man or pigmy, and to deal with these as zoological forms subject to the same variations of environment as so many larger groups of mammals. With this object in view the material and the methods of study claim attention: inasmuch as the former is at present limited almost entirely to the skeleton, we must commence with the study of this system, proceeding afterwards to the consideration of either material representative of, or data drawn from descriptions of other systems. As before, so in the present connection, the skull will be first considered, and we have now to take up the subject of Comparative Craniology and the methods employed in its elucidation.

(1) With a view to coordinating observations upon skulls, certain preliminary considerations must be submitted, and the first of these consists in the recognition of the fact that a skull, being roughly comparable to a cubical object, of necessity presents six surfaces for examination. The view obtained of any of these surfaces is defined as the norma of that surface, and consequently normae are recognised as follows; norma verticalis, the view of the vertex, from a point above the skull, this term was devised by Blumenbach; and to it were subsequently added, norma lateralis (the side view), norma facialis (the full-face view), norma basilaris (the basal view), and norma occipitalis (the back view of the skull). (Cf. Fig. 163.)
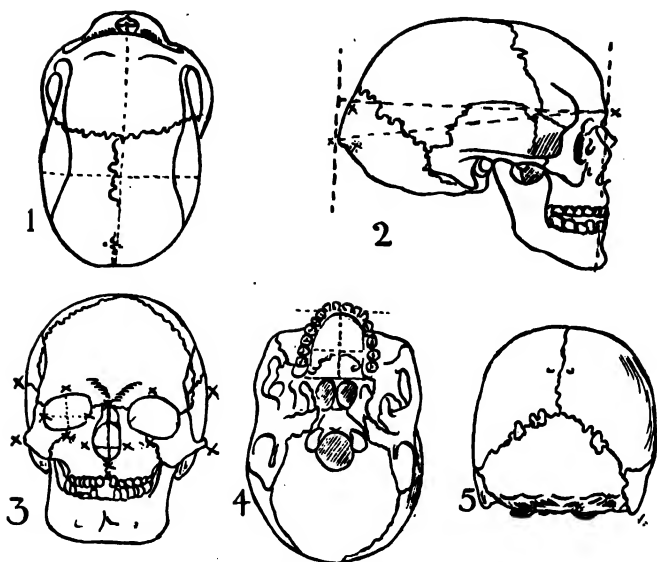
Fig. 163. The human skull viewed in (1) norma verticalis, (2) norma lateralis, (3) norma facialis, (4) norma basilaris, and (5) norma occipitalis. In (2) the skull is so placed that the " base line of the Frankfort agreement " (viz. the line passing through the lower margin of the orbit and the upper margin of the auditory meatus) is horizontal. The dotted lines in (2) represent the maximum cranial length, as well as the cranial length in a direction parallel to the " base-line," i.e. the cranial length in " projection," measured from the glabella anteriorly. The crosses in (3) mark the points between which the cranial, facial, orbital, and nasal widths, and also the orbital and nasal heights are measured. The dotted lines in (4) indicate the diameters of the hard palate, as measured conventionally in Flower's system.

(2) Secondly, the definition of certain points on the surface of the skull facilitates " regional " descriptions. The most important of these points are included in the following list, in which their positions are verbally defined. The numerical references are to Fig. 164.

Bregma. The point at which the sagittal and coronal sutures meet (1).

Obelion. A point in the sagittal suture midway between the parietal foramina (2).

Lambda. The point at which the sagittal and lambdoid sutures meet (3).

Inion. The most prominent point on the external occipital protuberance (4).

Opisthion. The mid-point on the posterior margin of the foramen magnum (5).

Basion. The mid-point on the anterior margin of the foramen magnum (6).

Prosthion. The most prominent point on the alveolar margin between the two upper median incisor teeth (7).

Akanthion. The most prominent point on the nasal spine (8).

Rhinion. The most prominent point at which the nasal bones touch each other (9).
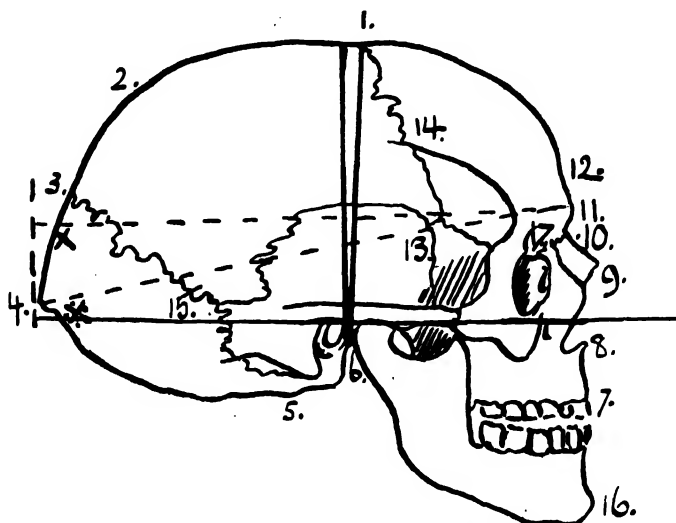
Fig. 164. Diagram of a skull with indications of the principal named points; the lines refer to certain measurements "in projection" to which further reference will be made in the text.

Nasion. The point at which the internasal suture meets the naso-frontal suture (10).

Glabella. The most projecting point of the frontal bone, at the level of the supra-orbital ridges (11).

Ophryon. A point in the median plane, and at the level at which the temporal ridges (which converge immediately above the external angular processes) are most closely approximated (12).

Pterion. A point at the posterior end of the parieto-sphenoid suture (13).

Stephanion. The point of intersection of the coronal suture and temporal ridge[1] (14).

Asterion. The point of confluence of the lambdoid, squamo-parietal and squamo-occipital sutures (15).

Pogonion. The most prominent point of the chin as represented by the mandible (16).

Dacryon. The point of confluence of the fronto-lacrymal, fronto-maxillary, and lacrymo-maxillary sutures on the inner orbital wall (17).

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[1] Where an epipteric bone is present the exact situation of this point is indeterminate.

A note on the derivation of the foregoing names may not be without interest.

Bregma. βρέγμα, βρέχω, to wet ; hence to soften. Hippocrates considers it is so called because this part of the skull remains soft longest.

Obelion. ὀβελός, a spit. Application obscure.

Lambda. From the resemblance to the Greek letter.

Inion. ἰνίον, the "tendon-point" from the attachment of the nuchal ligament.

Opisthion. ὄπισθε, the "hind"-point.

Basion. βάσις, the "base"-point.

Prosthion. πρόσθε, the "fore"-point.

Akanthion. ἄκανθα, the "spinous" point.

Rhinion. ῥίς, the "nostril"-point.

Nasion. *Nasus*, the "nasal" point. (A barbarism.)

Glabella. *Glaber*, smooth, from the smooth area round this point where the hairs of the eyebrows are deficient.

Ophryon. ὀφρύς, eyebrow. The "eyebrow"-point.

Pterion. πτέρον, the "wing"-point.

Stephanion. στέφανος, the "crown"-point.

Asterion. ἀστήρ, the "star"-point.

Pogonion. πωγώνιον, the "beard"-point.

Dacryon. δάκρυον (or δάκρυ), the lacrymal point.

(3) **Orientation.** In the third place, it is a matter of convenience to determine some definite position in which crania shall be placed for examination and comparison, for it is found that the eye may be greatly deceived as to such features as prognathism, frontal prominence or the reverse, by the amount of tilting forward or backward to which the specimen has been subjected. Several "planes of orientation" have been suggested, and in most cases a horizontal plane, determined by the natural conformation of the skull, has been sought: thus the plane of the "visual axis," and the alveolo-condylar planes (of which the names are sufficiently descriptive), have been used by some observers, the latter being particularly associated with the name of Broca. Less natural perhaps, but on the other hand more accurately horizontal and quite as easily defined, is the plane adopted by German observers, which is determined by the line passing from the inferior margin of the orbit in front, to the superior margin of the external auditory meatus posteriorly (cf. Fig. 165). It will however be

noticed that this line should be drawn on each side of the skull, and that owing to asymmetry of form, the four points (viz. two
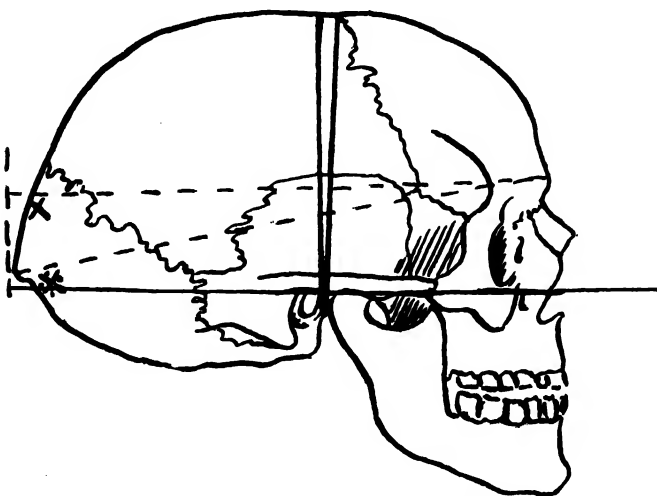
Fig. 165. Human skull placed in position, with the "base-line" of the Frankfort agreement in the horizontal plane.

infra-orbital and two supra-meatal) may not be strictly in one and the same plane. Allowance for this drawback has to be made, and the asymmetry which determines it must naturally occur in every object not constructed with absolute regard to strict geometrical principles. But the same objection applies to the other planes of orientation mentioned above.

The last mentioned plane is named from the determining line which is called the horizontal line of the Frankfort agreement (from the locality at which a conference of German observers drew up a system of craniometrical instructions): and it will be seen that when the skull is placed so that the plane determined by this line is horizontal, the natural resting position of the head of the living individual though inclined forwards rather than backwards, is nevertheless closely imitated. The recognition and determination of such a base-line is of much use in the comparison of cranial forms.

Being thus acquainted with the significance of the term norma and with the various normae, and recognising the named points

on the skull and the points by which the horizontal or base-line is determined, we may proceed to consider briefly the method of drawing up a craniological description.

The method here proposed involves the consideration of the skull as morphologically composed of, (*a*) the cranial part proper, consisting of such bones as are developed in connection with the coverings of the encephalon, (*b*) the derivatives of the visceral-arch skeleton, and first and second sense-capsules, which are collectively described as the facial portion; and (*c*) the cephalic portion of the axis of the skeleton, locally termed the basis cranii. Each of these divisions should be examined in turn, the appearances seen in the several normae being noted and particular features localised by reference to one or more of the named points (of which a list has been given). The accompanying scheme does not pretend to be exhaustive, but it has been found of practical use in the further systematisation of observations. It is moreover similar to the scheme adopted in the description of simian skulls in Chapter v. (*q. v.*).

I.   CRANIAL PORTION.

    General Contour : In norma verticalis this may present an elongated narrow appearance, or on the other hand be short or almost circular. In norma lateralis the transverse curve of the vault may be uniformly rounded, or it may be scaphoid, i.e. keel-shaped.

    Sutures : these may be absent : or be very tortuous, or almost rectilinear. They may be abnormal in number.

    Ridges : these vary considerably as regards their prominence.

II.   FACIAL PORTION.

    Orbit : General contour and margins : the cross diameters of the orbital aperture may be nearly equal, or the vertical may be much less than the horizontal.

    Lacrymo-ethmoidal suture : this may be short, or long, or absent, when a fronto-maxillary suture usually replaces it.

    Lacrymal hamulus : very variable in size, more usually small than large.

    Infra-orbital suture : variable in persistence.

    Nasal aperture :

    General contour ; ovoid, pyriform or cordate.

    Lower margins : distinct or obliterated, with or without subnasal fossae.

Nasal spine : variable in prominence.

Nasal bones : variable in size and shape.

Palate.   General contour: this may be elliptical, hypsiloid or parabolic according as the two alveolar arcades are convergent, parallel or divergent.

Post-palatine spine : variable in prominence and sharpness, often notched.

Tuber maxillare : variable in size.

Palatine sutures: frequently depart from the cruciform arrangement described in text-books.

III.   THE TEMPORAL FOSSA.

Sutures at pterion : these may assume an H-form, inverted H[1], or X.

Depth of fossa : variable and dependent on several factors.

Post-orbital wall : variable in degree of completeness.

IV.   BASE OF THE SKULL.

Glenoid fossa : sometimes very shallow.

Margin of foramen magnum : such variations as accessory articular facets for the atlas (posterior arch) or the odontoid process of axis are to be remarked.

Styloid process : variable in length.

V.   DENTITION.

Number of teeth.

Characters of teeth.

VI.   THE MANDIBLE.

The foregoing characters having been noted, the evidence provided in this manner is to be brought to bear, first upon the approximate age of the individual, i.e. whether still infantile, or at the age of puberty, or mature; secondly, upon the question of sex; and thirdly upon the general status of the specimen as judged by its morphology.   A fuller discussion of these three subjects will provide material for subsequent chapters (Nos. XI. and XVI.).

These remarks will furnish some idea of a scheme which has proved of practical use both in research and instruction, and the several anatomical points contained in the various sections are accompanied by the briefest of statements as to what should be specially recorded.   Very many other characters might be added to the list, but it is believed that those just enumerated are the most valuable for the purposes described.

The outcome of these observations as regards the human skull

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[1] The letter H placed on its side was thus described by Broca.

in comparison with those of the Simiidae for instance, may be gathered from references to the description of the skulls of Simiidae given in Chapters IV. V. and VI., while the results of such investigations when directed to the skulls of various types of humanity will be considered in a later chapter.

While an historical account of the development of the comparative study of skulls is without the scope of the present work, it may be noted that the subject is dealt with certainly as early as the sixteenth century by Vesalius, though the fanciful may claim Herodotus or even Homer[1] as the earliest craniologist. In our own time, descriptive craniology has been largely supplemented by craniometry, an account of the methods of which naturally follows in this place. Nevertheless certain observers, who have achieved no little notoriety in this field, have almost absolutely rejected numerical or craniometrical methods. Chief among these is the Italian Sergi, who has elaborated a system devised originally by von Baer at Göttingen at the beginning of the nineteenth century. But Sergi has carried the purely descriptive method to such an extreme as renders its use almost impracticable, owing to the minuteness of detail which suffices for the creation of new specific cranial types, and their consequent multiplication. In spite however, of this objection to craniometry, we must note that Sergi retains measurements of capacity. We shall see in the sequel that the craniometrical method has been similarly extended to an exaggerated degree, with a somewhat similar result as regards its practical utility.

In this study (Craniometry), which consists essentially in supplementing descriptive by numerical data, we find at once that several distinct groups of methods claim attention. For distinctions must be drawn between the several kinds of measurement employed, and thus we are led to the recognition of measurements which may be described in order as

(1) rectilinear,
(2) curvilinear,
(3) angular,
(4) cubical, or measurements of capacity,
(5) ponderal, or measurements of weight,

[1] Herodotus, Book III. chap. xii; Homer, *Iliad.* II. 219.

and a few words of explanation may now be added in relation to each of these classes[1].

(1), (2). **Rectilinear and curvilinear measurements**: these are so closely allied that they may be considered together. It seems very natural that the inspection of a skull, with a view to measuring it, should result in the posing of the questions " How long, broad, and high is it ? " or " how much does it measure round ? " the answers to these questions are arrived at by the aid of measurements of length, breadth, height and circumference, and these are in fact the most firmly established measurements in systems of craniometry. One finds moreover that any one of these four dimensions will vary, according to the plane in which the measurement lies, so that numerous measurements of the length as well as of the breadth, height and circumference of the skull have been devised. But whatever be the particular measurement adopted, one should be guided in its selection by considerations of its value as expressive of the proportions of the brain by which the skull is protected.

It will be noticed that although not based upon strict considerations of morphology, measurements were soon made upon

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[1] A brief note on the historical aspect of Craniometry (as distinct from simple Craniology) is appropriate here. The earliest record is probably that of Bernard de Palissy (1563), who suggested, though he did not apparently practise, cranial measurements. In 1600, Spigel made similar suggestions with a view to expressing differences in skull-forms by this method. In both these instances only human crania were taken into account. Tyson (1699) made some measurements of the skull of the Chimpanzee dissected by him (cf. Chapter i. foot-note); and in 1764, Daubenton published observations of great importance dealing with the relative position of the foramen magnum in the lower animals and in man (cf. Chapter v. pp. 114 to 119); lack of precise methods in making measurements somewhat vitiated the value of Daubenton's work. He was followed by Peter Camper (1722–1789), to whose work, including the "method of projection," and the description and measurement of facial angles (he devised at least two), allusion has already been made; and in subsequent succession come the names of Cuvier and Geoffrey S. Hilaire, to whom credit is due for having made comparative craniological investigations on the Primates, utilising an angular measurement since associated with their names. While Blumenbach paid less attention to measurement than description, the Swedish anatomist Retzius made important craniometrical observations in the earlier years of the XIXth century, and we are thus carried to the days of Broca, Lucae, and modern observers too numerous to mention.

the cranial as distinct from the facial part of the skull: but it was not till distinct advances had been made in the morphological study of the skull, that guidance in the selection of appropriate measurements was obtained. Measurements whether of the spheroidal cranium, or of the face and mandible, were rapidly augmented in number, and when it is added that the actual operation of making measurements demands no high degree of manipulative skill, nor, when undertaken empirically, as has so often happened, does it involve very extensive preliminary experience or prolonged preparatory study, it is easily intelligible that such augmentation might occur as has actually been the case, and that, as is also the case, thousands of measurements have been published though accompanied by very little elucidative literature. Empiricism was once the order of the day; as a guiding principle it proved unproductive; indeed it has brought craniology into disrepute. To the definite enunciation and application of morphological principles to craniological studies and craniometrical methods we owe much to British observers, among whom Huxley, Flower, and Turner must be specially mentioned, while progress in this respect has been indirectly due to all whose work has contributed, like that of Gegenbaur, Lucae, Cleland, and Topinard, to the fuller knowledge and appreciation of cranial morphology.

With these introductory remarks we may pass to the appended list of rectilinear and curvilinear measurements, a list of no great length, but yet containing the measurements believed to be of most importance from the stand-points of research, of demonstration, and instruction.

Dimension.	Method of Measurement.
CRANIAL PORTION.	
Maximum length.	From the glabella to the most prominent point of the occiput in the median sagittal plane. Crania of women and children may occur in which the maximum length will pass from the *upper part* of the frontal bone (above the ophryon and glabella) to the occiput.
Maximum breadth.	Measured on the cranial part (not the face) above the auditory meatus, and usually on the parieto-squamous suture.

Dimension.	Method of Measurement.
Basal height.	From basion to bregma.
Auricular height.	From the inter-auricular line to the bregma.
Horizontal circumference.	The flexible measure passes along the brow-ridges and glabellar prominence in front, and over the projecting portion of the occipital bone behind.

FACIAL PORTION.

Auriculo-nasal length.	From the inter-auricular line to the nasion.
Auriculo-prosthionic length.	From the inter-auricular line to the prosthion.
Basi-nasal length.	From basion to nasion.
Basi-prosthionic length.	From basion to prosthion.
Nasi-prosthionic length.	From nasion to prosthion.
Bi-zygomatic breadth.	Greatest diameter of zygomatic arches.
Bi-stephanic breadth.	From stephanion to stephanion.
Orbital height.	The maximum vertical height of the orbital aperture.
Orbital width.	From the dacryon to the outer margin of the orbital aperture, at right angles to the preceding line.
Nasal height.	From nasion to akanthion.
Nasal width.	The maximum width of the nasal aperture.

As in descriptive craniology, the divisions of cranial and facial portions of the skull have been recognised. With the names of the measurements in the foregoing list instructions and definitions are given, to which may be added a few remarks in the present place. It will be noticed that in several instances the measurements are made between points to which are applied the particular names detailed at an earlier period in this chapter; in perusing the instructions for making the measurements, reference is thus necessary to Fig. 164 respecting the positions, and to the list of definitions of those points, which therefore need not be recapitulated in the present connection.

Maximum length, maximum breadth. These measurements, and indeed all the others in the list with the exception of the horizontal circumference, are most conveniently made with the aid of a pair of callipers such as Flower's Craniometer (Fig. 166), or the model more commonly used in Germany (Fig. 167).

Besides the maxima, various other measurements have been suggested both of length and breadth, such as the ophryo-occipital,

or the ophryo-iniac, the nature of which is indicated by their names
(they are determined by the ophryon anteriorly, and not by the
glabella); but on the whole it has not been shewn that they are
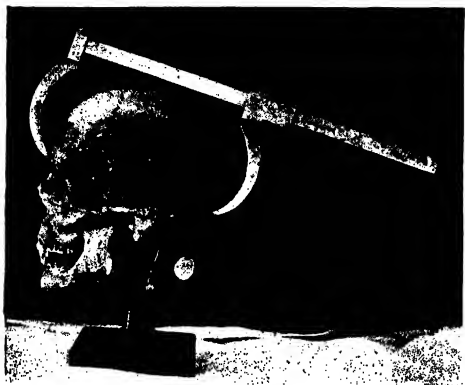
Fig. 166.   Fig. 167.

Fig. 166.   Flower's Craniometer in the position for measuring the maximum
cranial length.

Fig. 167.   A second variety of Craniometer.

of greater value than the maximum length, though no doubt they
supplement the information conveyed by the latter measurement.
To the description of the mode of measuring the maximum
breadth, it should be added that this breadth is practically always
in excess of the diameter at the base of the mastoid processes,
which may be considered as the diameter of the skull-base,
a chord which is less modified by the growth of the encephalon
than that measured higher up between points in the membrane-
bones of the skull-cap.

Basal height. This measurement might be made from the
basion in a plane at right angles to the horizontal plane as defined
by one or other of the methods mentioned in the note on "orien-
tation"; but as a matter of practical utility the results afforded
by the basi-bregmatic height are not appreciably inferior to those
yielded by the strictly vertical height.

Auricular height.   To make this measurement, Cunningham's craniometer or Pearson's head-spanner must be used.   As indicated in the note appended to this measurement in the list (*q.v.*), the object in view is to determine the distance separating the bregma from the inter-auricular line, i.e. the line drawn from the centre of one auditory meatus to the other.   The instrument (cf. Fig. 168) consists of the following parts.   Two bars (A and A') are
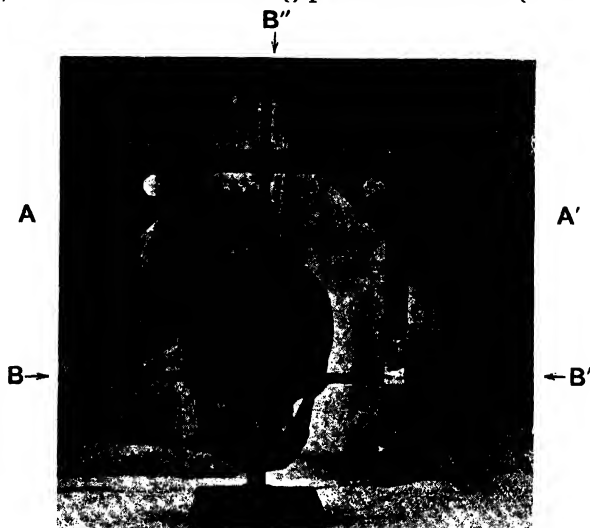
Fig. 168.   Pearson's head-spanner in the position for measuring the auricular cranial height.

joined by a crosspiece about 200 mm. long, so that the bars and crosspiece form a frame representing three sides of a square.   At their free or lower ends, A and A' carry geometric slides in which slender rods (B, B') play towards, or away from each other, and at right angles to A and A', but always in the plane of the frame. B and B' are terminated at their inner ends by conical tips adapted to the form of the auditory meatus.   The crosspiece also bears, at its middle point, a geometric slide in which a graduated rod B'', similar to B and B', plays at right angles to the crosspiece, but like B and B', in the plane of the frame.

In using the instrument, B and B' are first separated to admit of a skull being placed between them and then they are approxi-

mated till their conical ends enter the meatus each side. Rotating
on B and B' as an axis, the whole frame can now be moved for-
wards and backwards over the skull. Two adjustments are now
necessary: in the first place B and B' are moved so that the mid-
point of the crosspiece and B'' are in the median sagittal plane of
the skull: and secondly, B'' is moved towards the skull till any
desired point in that plane is touched. Here the bregma is the
point in question, and B'' is so graduated as to give directly the
distance of the bregma from the line joining B and B', i.e. the
inter-auricular line.

Horizontal circumference. This measurement is made with
a flexible measure of steel or linen; the latter material is less
exact, for it is liable to stretch, yet its employment is justified by
the fact of its fitting more closely the form of the skull than the
more rigid metallic ribbon does. The maximum circumference
including the glabellar, supra-orbital, and occipital prominences
is measured. The measurement of the horizontal circumference
as made by Flower does not include
the glabella. The retention of this
particular method is not justifiable in
view of what has just been written
regarding the measurement of maximum
length, and it is only retained because
of the existing comparative data, a
consideration of much less force in the
case of the maximum length. Turner
measures the maximum circumference
(Fig. 169) as described above (v. p. 237).
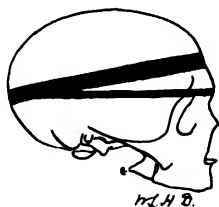
Fig. 169. Diagram in which
the broad band represents the
line of the horizontal circum-
ference according to Flower;
the narrow band represents the
line adopted by Turner and
described in the text.

The auriculo-nasal and auriculo-
prosthionic lines are measured with
Pearson's or some similar craniometer, and represent the radii
from the ear to the nasion and prosthion respectively. Their
value depends largely on the consideration that the corresponding
measurements are easily made on living subjects (cf. *infra*,
Chapter XIII. "Anthropometry").

• The basi-nasal length is important as representing the length
of the cranio-facial axis. The only objection that might be urged

against it, is that the nasal bones are liable to variations in vertical extent, and that the position of the nasion (which determines the line) is in consequence subject to variations which are only remotely connected with those of the bones of the cranio-facial axis. In man these variations are probably only slight, but in the Simiidae they are more important, and hence introduce an element of uncertainty into comparisons of the Hominidae and Simiidae based on the actual dimensions (though less on those based on the position and relations) of this line.

The basi-prosthionic and nasi-prosthionic lines complete a triangle which may be termed the facial triangle.

The next two measurements are diameters of the cranial and facial portions of the skull respectively, and are chiefly of interest when compared with one another, as described in the sequel (cf. Chapter XI.), as the stephano-zygomatic index.

The orbital and nasal measurements were devised to represent the proportions of the height and width of the orbital and nasal apertures respectively: it may be mentioned that the orbital-width-measurement includes the whole of the lacrymal bone within the orbit. Upon morphological grounds this is incorrect, and it has been urged that the line of the crest or ridge on the lacrymal bone should be taken, so that the measurements should include but one half only of the bone within the orbit. The position of the dacryon is however so definite, and the difference between the two alternative diameters so slight, that the simpler line, as more easily measured, has been retained in the foregoing list.

It will doubtless be remarked that in the preceding notes no mention is to be found of the principle of making measurements in projection, nor has the method of projections been recommended in this connection. The method may be briefly explained in reference to the example of the measurements recommended by the Frankfort Congress. In the first place the skull to be measured is so orientated that the base line is horizontal (cf. Fig. 170). Suppose that the length and height (basal) of the skull are to be measured. Ordinarily, the maximum cranial length from the glabella[1] would be measured: "in projection," however, the dimension measured is the length from the glabella

[1] Between the points marked 11 and 4 in Fig. 170.

to the occipital end of the skull, *in a plane parallel to that of the base line*[1]. In regard to basal height, the height measured from the basion is, according to our system, the basi-bregmatic height[2],

Fig. 170. A human skull in which the principal points are indicated by numerals. The line from 11 to 4 is the maximum length of the cranium: that from 11 to × is the length "in projection." The line from 1 to 6 is the basi-bregmatic height: the line immediately behind this is the height "in projection."

and in the diagram is represented by the line drawn between basion and bregma. In projection, the basal height is the height of the line drawn from the basion *perpendicularly* to the base line, and is accordingly shewn by a line in the diagram cutting the top of the skull at a point which does not coincide with the bregma. The method of projections demands that all measurements shall be in planes parallel or perpendicular to the horizontal plane of orientation determined by the base line. Such a refinement is undeniably a step in advance as regards accuracy of comparison and uniformity of treatment. But against these advantages we have to set off the increase in labour entailed for the measurements, and when it is added that the results of the more complicated system have not as yet been shewn to be markedly superior

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[1] Between the points marked 11 and × in Fig. 170.

[2] Between the points marked 1 and 6 in Fig. 170.

to those simpler methods described in the text; it is submitted that there is justification for adherence to the latter.

(3) **Angular measurements.** From linear measurements we pass to the measurements of angles. From a considerable number of angles of which descriptions have been given we shall select five, the choice being determined by the value of the angle as illustrative of morphological conformation and its variations from skull to skull.

The best known of these angles is the facial angle, which is used as a means of illustrating the difference between the projecting "prognathous" facial skeleton of various animals and the corresponding portion of the skull of the Hominidae. The term "facial angle" is no longer new: tradition ascribes to Albrecht Dürer the description and employment of a facial angle[1] in artistic studies: but there is no doubt that the capabilities of this method of comparison were originally recognised by the Dutch artist and anatomist Peter Camper (to whom reference has already been made) in the eighteenth century. As described by Camper, the facial angle was determined upon the intact skull, unmodified, that is, by any section having been made. But it is to be noted, that the median sagittal section of the skull provides a plane surface revealing several morphological characters susceptible of illustration by means of angular measurements, also conveniently made on such a surface. We must therefore distinguish angles measured on the external surface of the skull from those determinable upon sections of the kind just described. Camper's facial angle is an example of the former variety, and though the including lines as defined by Camper have been amended, and various other facial angles of a similar nature have been proposed, we shall describe it with one other in the list of angular measurements to be made on non-sectionized skulls.

The facial angle of Camper is included by two lines (cf. Fig. 2), viz., a facial line, and a base line or "horizontal" line. The facial line is tangential to the most prominent part of the frontal bone in the neighbourhood of the glabella, passes downwards, and is tangential to the slight convexity forwards of the upper incisor teeth: the lack of definition of the latter (lower) point is due to

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[1] And it is certain that this artist made use of a facial line, on the subject of which he wrote a treatise.

the fact that the angle was described by Camper as determinable upon the head when clothed with the soft tissues as in life, just as conveniently as upon the macerated skull.   The facial line in the head passed through the point of contact of the lips (as seen in profile): this is best represented by the most anterior point on the surface of the upper incisor teeth, and this consideration has determined its selection in the skull[1].

The horizontal or base line adopted by Camper passed through the lower part of the nasal aperture, backwards along the line of the zygomatic arch, and through the centre of the external auditory meatus, and in the case of the measurement being made upon a head, the line approximately corresponds to that of the nostril as seen in profile[2].

The two including lines are found to intersect in the neighbourhood of the nasal spine, and the angle thus formed was shewn by Camper to vary from a comparatively small number of degrees representing its value in the skull of a lowly mammal or reptile, ascending through the higher Mammalia, and the apes, and thus gradually through the negro to the white human type, culminating in the idealised heads which Greek artists of antiquity gave to their masterpieces of sculpture.

With the remark that a weighty objection to this angle was the lack of definition of the points by which its including lines were determined (and in particular the presence of the incisor teeth is essential in this respect), we pass at once to the consideration of another facial angle, the including lines of which are more definitely fixed.   The facial angle recommended by the members of the Frankfort Congress is included like that of Camper, by a facial line, and a base-line.

The facial line passes through the nasion above and the prosthion below: the horizontal or base line is that already defined

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[1] Camper's description is not quite clear: it runs as follows (cf. *Camper's Works*; ed. by Cogan, 1821): "As the closing of the teeth marks the mouth at 'G,' I was able to draw an oblique line from 'G' to 'M' along the nasal bone of the forehead."   But inspection of the diagrams leaves no doubt that the meaning is that given in the description above.

[2] Topinard remarks that the base line of Albrecht Dürer, passing through the lower part of the nose and through the lowest part of the lobe of the ear, is more exactly horizontal than Camper's line.

as the base line of the Frankfort agreement, and passes through the infra-orbital margin and the upper margin of the external auditory meatus. Like that of Camper, this angle may be determined upon the head as well as on the skull, and the results of a comparison of its value in various animals are similar to those derived from the study of Camper's angle.

Before passing from the description of the angles measured on the skull exteriorly to the consideration of angles determinable only upon median longitudinal sections, it must be noted that the angles of Camper and of the Frankfort agreement (the latter may be termed the Frankfort angle) are in practice best determined by measurement upon projected drawings whether of head or skull. Ranke's goniometer is an instrument specially devised for the purpose of measuring such angles, but (without raising objections on the score of the costliness of the instrument) it is submitted that equally good results are obtained upon projected outlines, and the latter method was actually practised by Camper. The stereograph affords an excellent means of making the desired drawings (this applies to sectionized as well as to intact skulls), and it is not necessary to draw a detailed contour, nothing more being needed than an indication of the four points defining the two lines by which each angle is included. The simplest method of making such a projection-drawing is to place the object on a sheet of paper and to run a pencil, perpendicularly to the paper, round the circumference of the object. But where the object is not adapted
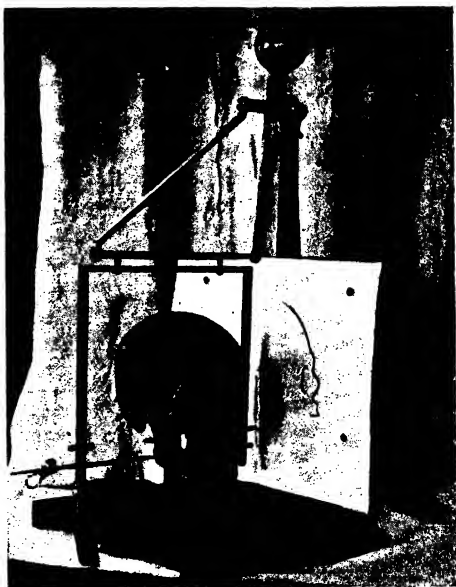
Fig. 171.

to the plane surface of the paper it must be held in position. The stereograph (cf. Fig. 171) consists[1] then (*a*) of a craniophore or skull-holder; secondly (*b*) of a drawing-board on which the paper for receiving the drawing is pinned, and lastly (*c*) of a frame in which the pencil is held accurately and perpendicularly to the plane of the paper. When we add that the frame is so modified as to admit of other features than the circumferential contour being drawn in, an idea will be gained of the nature and capabilities of the instrument of which a figure is appended[2].

It will be apparent that when angles are to be measured no contour is necessary, all that is required being the position of the several points by which the lines are determined; these can be indicated very rapidly and accurately, and the desired lines drawn upon the paper.

We now pass to the angles measured on the sectionized skull. A retrospect of the remarks (cf. Chapter VI.) on the appearance of the component parts of the skull as revealed in a median longitudinal section, shews that the principal elements displayed may be classified under the three categories, or three portions of the base, known as the anterior base, middle base, and posterior base respectively. It will further be remembered that from the comparison of various skulls the inference is drawn, that in evolution, changes have occurred in the inclination of the several segments of the cranio-facial axis represented by the anterior and middle bases respectively. The angles now to be described are measured with the object of obtaining numerical expressions for the degree of inclination in such examples; as well as for the demonstration, with the aid of numerical data, of the mode and degree of transformation observed from skull to skull, whether the subjects of comparison be human and other animal skulls, or the comparison be confined within the limits of the Hominidae. For such purposes several angles have been devised, but the three which follow are considered ample for all practical purposes.

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[1] *v.* also *supra*, Chapter I. (p. 9).

[2] Another method was devised by Camper; the object is placed behind a frame across which strings are stretched: the drawing is made on paper, with lines corresponding to the strings, marked upon it. This method has been elaborated in the instruments of Lucae in Germany, Matthew in the United States, and Martin in Switzerland.

It may be repeated that the surface of section (cf. Fig. 172) presents the following points of importance, viz., N, the nasion, Pr, the spheno-eth-moidal junction (the upper-most limit of which may be designated the prosphenion), B, the basion, and Op, the opisthion: and that the line from nasion to prosphenion represents the "anterior base," the line from prosphenion to basion the "middle base," and that from basion to opisthion the "posterior base"
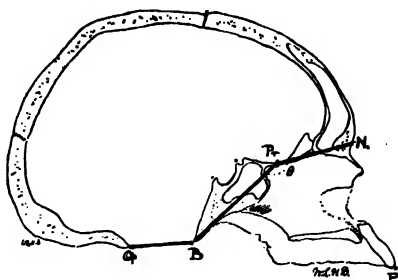
Fig. 172.   Mesial section of the skull of an aboriginal of Australia, shewing the three divisions of the cranial base, viz. Pr—N, B—Pr, and Op—B: and the spheno-ethmoidal angle (θ).

according to the system of nomenclature devised by Cleland. We have seen that in the process of evolution, the portion repre-sented by the anterior base of the cranio-facial axis has been inflected upon that indicated by the middle base: and that the inclination of the middle to the posterior base has also varied.   It remains to draw the lines representing the several bases and to measure the angles included by these lines.   Thus between the anterior base[1] and the middle base an angle is included which is called the spheno-ethmoidal angle (cf. Fig. 172, θ).   This angle is regarded as salient upwards and backwards, so that in the Hominidae its value falls short of 180°.   Between the middle base and the posterior base is the angle known as the foramino-basal, which is regarded as salient downwards, and thus like the spheno-ethmoidal angle does not amount to the value of two right angles (180°) in the human skull.

One angle remains, viz. the spheno-maxillary, included by the lines drawn from basion and prosthion respectively to the pro-

[1] Apropos of this angle, it will be remembered that the determination of the "anterior base" by the nasion, is attended by the disadvantage that the nasal bones extend to a very variable degree upon the surface in different skulls: a point more suitable for determining the anterior end of this part of the cranio-facial axis would be perhaps the margin of the foramen caecum, as a substitute for the nasion; but in view of the inconstancy of this, and of the small probable difference in the results of measurements, the nasion may well be retained as originally described.

sphenion. This angle affords a most excellent measure of prognathism, and is to be preferred before the facial angles measureable upon the non-sectionized skull. Unfortunately but few comparative data for this (the spheno-maxillary) angle exist. The numerical values of these angles in terms of degrees will be mentioned in the sequel.

" The so-called facial angle, in fact, does not simply express the development of the jaws in relation to the face, but is the product of two factors, a facial and a cranial, which vary independently. The face remaining the same, prognathism may be indefinitely increased, or diminished, by the rotation of the frontal end of the skull, backwards or forwards, upon the anterior end of the basi-cranial axis[1]."

The spheno-ethmoidal and spheno-maxillary angles are associated with Huxley's important research on the cranio-facial axis: the foramino-basal angle is associated with the name of Turner[2]. While omitting detailed descriptions of the angles historically older, we have already alluded to the work of Daubenton in the 18th century, on the inclination and position of the foramen.
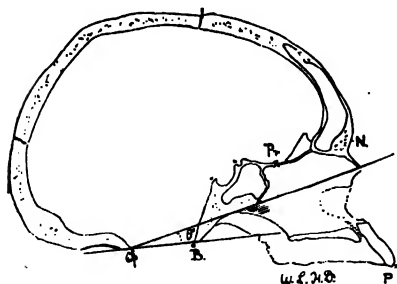
Fig. 173.   Fig. 174.

Fig. 173. The same specimen as that shewn in Fig. 172, to indicate the angle of Daubenton (θ'').
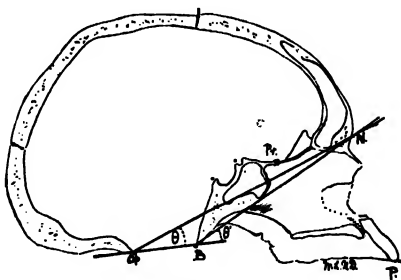
Fig. 174. The same specimen as that shewn in Fig. 172, to indicate the occipital angles (θ and θ') of Broca.

magnum in the crania of mammals, and the later development of this subject by Broca, from which we derive the occipital angles of Daubenton and Broca (cf. Figs. 173 and 174); historically of

[1] Huxley, *Journal of Anatomy and Physiology*, Vol. I.
[2] *Challenger Reports*, Human Crania.

interest also are the researches which gave rise to the invention of
the angles of Landzert, of Virchow, and of Welcker.   The facial
angle recently mentioned by Keith[1] corresponds to none of those,
nor to the spheno-maxillary angle of Huxley, to which it cannot
be considered superior[2].

(4)   **Measurements of Capacity.**   From angular measure-
ments we turn to measurements of capacity : such measurements
have been applied to the endocranium and to the orbital cavity :
but the first of these only need detain us here (the capacity of the
vertebral canal of the spinal column being considered in another
connection).   The simplest way of determining the capacity of the
skull is to plug all foramina and orifices save the foramen magnum,
and to fill the skull with some suitable substance which can then
be withdrawn and measured in a graduated vessel.   Experience has
shewn however, that the results are very variable, and that the chief
sources of error are dependent on the nature of the substance used
to fill the skull, the personal equation of the observer, affecting the
tightness of packing both the skull and the vessel in which the
contents of the skull are subsequently measured.   To obtain
trustworthy results, therefore, care must be exercised in regard to
these points : of the various materials used, No. 8 shot is perhaps
the best, though peas and various other seeds and even sand have
been used.   The shot is always to be poured in through a funnel
of certain dimensions, and the process of shaking the shot into
place and arranging it with a wooden rod are to be made as
uniform as possible.   Unsatisfied with the results and in view of
the conditions which exclude fragile skulls from measurement,
certain observers (such as Benedikt in Vienna and Poll in Berlin)
devised a method whereby an india-rubber bag was introduced
into the cavity of the skull and then inflated with water under a
pressure which was made constant in a series of observations.
This is certainly a better method than the older and simpler one,
but has the disadvantage of necessitating somewhat costly appara-
tus, while the possible perforation of the india-rubber bag under
tension by some endocranial spicule of bone necessitates great care

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[1] *Human Morphology and Embryology*, p. 173.

[2] The very important frontal and bregmatic angles, devised by Schwalbe, will be
considered in Chapter xvii.

in manipulation.   At the present time another method of obtaining
a measure of cranial capacity is available and it is one which
depends upon the linear dimensions of the skull. Topinard puts
the matter in the following way.   Supposing that one multiplies to-
gether the length, breadth and height of a skull, one obtains a figure
which represents the contents of a parallelopiped having these
dimensions.   This figure divided by 2 would give approximately
the contents of the[1] sphere that could be contained within this
parallelopiped figure : or if this divisor (2) be mutiplied by 1·175
the volume of an ellipsoid body would result,   But in consideration
of the facts that the cranium is neither precisely spheroidal nor
ellipsoidal, and that the thickness of the skull wall has to be
allowed for in estimating capacity, the result is not reliable.   An
empirical value for a factor which should replace the figure 1·175
was sought by Broca, who obtained the figure 1·12, and this was
subsequently shewn by Manouvrier to vary in the sexes, 1·135
being the more correct figure for the male, 1·108 for the female
skull.   This factor is introduced into the formula,

$$\text{Capacity} = \frac{\text{Length} \times \text{Breadth} \times \text{Basal Height}}{2 \times 1\cdot135 \ (\text{or } 1\cdot108)},$$

and is stated by Topinard to be correct to within 4 %.

Inasmuch as the total figure is represented by about 1500 c.c.,
the error may thus be as much as 60 c.c., no inconsiderable amount,
but not conspicuously greater than occurs in the old method when
great care is not exercised.   It is to be noted too that the formula was
devised primarily for French crania and will almost certainly need
modification for other skulls.   Quite recently, a pupil of Karl
Pearson (Dr A. Lee) has resumed observations, and using the
auricular height instead of the basal height, has published for
German and Egyptian skulls, formulae of much greater value and
accuracy than the foregoing.   The values of the capacity of crania
will be the subject of further mention in the next chapter.

(5)   It remains to consider the method of weighing, and in this
connection it may be mentioned that the skulls, mandibles, and
other bones of various animals and of man have been weighed, the
results tabulated and compared.   The value of the results depends

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[1] Presumably the greatest sphere.

on those comparisons, the consideration of which does not come within the scope of the present chapter.

We have thus briefly reviewed the fundamental principles of comparative craniology, and insisted that comparative human craniology must be based on similar considerations of morphology to those which determine comparison of human with other crania. From this we passed to the numerical methods, dealing particularly with those best adapted for recording morphological structure in a form suitable for comparative studies. We are now in a position to consider the uses to which such data may be put, after they have been made and collected according to the instructions given.

APPENDIX TO CHAPTER X.

CRANIAL DEFORMATIONS.

CRANIAL deformations are met with in most collections of human skulls, and as they vary considerably in respect of causation as well as in appearance, the following remarks are appended with a view to affording some guidance in the diagnosis of examples of the cases of most frequent occurrence.

Distorted or deformed crania may be best classified according to the scheme first devised by Turner, of which the following is a modified form.

I. Synostotic deformation: this is consequent upon irregularities of cranial development, accompanied by precocious union of two or more cranial bones.

II. Artificial deformation, consequent on compression applied in infancy.

III. Pathological deformation; the result of disease.

IV. Posthumous deformation; due to the pressure exerted by the soil surrounding a skull after interment.

I. Synostotic deformation. Synostosis of the cranial sutures may be either precocious or retarded. In the event of premature synostosis, some deviation from the normal cranial form is very

common, and a general rule has been formulated (by Virchow) to the effect that premature synostosis is followed by restricted growth in a direction perpendicular to that of the synostosed suture.   Thus if a longitudinally-directed suture be closed by premature synostosis, the skull-growth in the transverse or coronal direction will be checked.   Should the coronal or other transversely-directed suture be thus obliterated restriction of growth in the sagittal direction will ensue.

(*a*)   Scaphocephalus (cf. Fig. 175): probably the commonest deformation associated with premature synostosis.   There may be an appearance of annular constriction (see under Klinocephalus), and the specimens are always dolichocephalic, the narrowness which gives this character being due to restricted growths transversely, in accordance with the law formulated above, following upon closure of the sagittal suture.

Though scaphocephalus is so often the associate of premature synostosis, yet this is not always the case, for in many scaphoid (scaphocephalic) crania, the sagittal suture is not obliterated.   Good examples of this may be seen in collections of crania of Greenlanders, or of Oceanic negroes or aboriginal natives of Australia. Conversely, the sagittal suture may be entirely obliterated without the production of scaphocephalus, so that the foregoing statements are evidently liable to numerous qualifications and possess a general significance only.

(*b*)   Klinocephalus (cf. Fig. 176): when the fore-part of the sagittal suture is closed prematurely and at the same time the parieto-sphenoidal suture also disappears, the growth of the skull is arrested locally, at the sides and top; this results in the production of a depression encircling the skull as though a band had been tightly applied.   A slight degree of this deformity seems to be very common in female skulls of whatever race.   The character is sometimes referred to as " annular constriction," and is quite distinct from the artificial deformation produced by bands, in which the sutures remain open.

(*c*)   Trigonocephalus (cf. Fig. 177): where the inter-frontal or metopic suture closes prematurely, there may ensue localised arrest of transverse growth; the frontal region will then remain narrow and stunted in growth, while the posterior parts of the

cranium expand normally.   The result is the production of a skull which viewed from above presents a peaked or rostrated appearance and has been described as triangular or trigonocephalic.   It is worth notice that the suggestion has been made that the skull of the fossil Pithecanthropus erectus partakes, to a slight degree, of this character.   (Cf. Chapter XVII.)
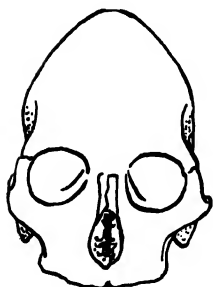
Fig. 175.
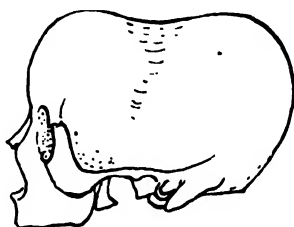
Fig. 176.
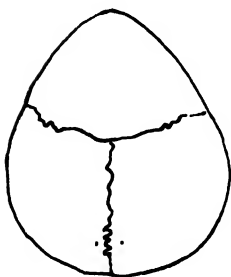
Fig. 177.

Fig. 178.

Fig. 175. Scaphocephalus.   Fig. 176. Klinocephalus and annular constriction.
Fig. 177. Trigonocephalus.   Fig. 178. Plagiocephalus.

(d)   Plagiocephalus (cf. Fig. 178).   The skull is asymmetrical. In typical cases there is closure of part of the coronal suture at a premature stage : the arrest in growth is then unilateral and the skull becomes flattened on one side, while in compensation the opposite side projects.   In extreme examples almost a reniform outline is produced.

But asymmetry is not always associated with premature synostosis. Slight degrees of deformation of this kind may be possibly produced in childhood, if the infant lies habitually on one side rather than the other. Injuries, disease, and pressure of soil after interment must also be considered in the category of productive factors of asymmetry.

(*e*) Thyrso- or Akro-cephalus (cf. Fig. 179): the bones of the cranial vault are upraised, so that the height of the skull is much increased. These crania are usually very brachycephalic, and the coronal suture is often closed, while part of the sagittal (near the bregma), and the basilar sutures may partake in the synostotic processes
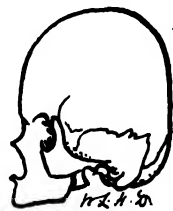
Fig. 179. Thyrsocephalus.

In the foregoing deformations the cranial capacity is little if at all modified: the central sulcus (of Rolando) does not bear a constant relation to the coronal suture considered as its superficial landmark.

II. Artificial deformations: in these, pressure is artificially applied in various ways and to various regions of the head. Thus the pressure may be

(*f*) Frontal: exercised by means of a board, as for example, among certain N. American Indians; probably the deformed crania of Mallicollese, of prehistoric Avars, and Makrocephali of the Crimea are attributable to a similar cause.

(*g*) Fronto-occipital: pressure exercised in front and behind the head: there are bi-lobed and tri-lobed varieties, in which a rod, being substituted for a flat surface, indents the young head to which it is applied. The most striking examples are found among American aborigines.

(*h*) Annular: due to a bandage wrapped round the head: examples occur in France (Toulouse) and Switzerland as well as in more remote lands, such as Borneo.

(*i*) Plagiocephalic: where the compression is unequally exerted and the deformation is asymmetrical.

(*j*) Platybasia: the deformation in which the basis cranii appears to be thrust up into the cranial cavity: this variety of deformation is however more commonly associated with defects in

the texture of the bones, and thereby enters more fitly into the next class.

III.   Pathological: this group includes many plagiocephalic and most platybasic forms.

(k)   Hydrocephalus: excessive and even expansion of the constituents of the cranial walls; many wormian bones[1] are commonly developed to make good the gaps formed along the sutural lines by the separation of the bones in consequence of the expansion.   The ventricles of the brain are distended with cerebro-spinal fluid, and the varieties of hydrocephalus have been classified according to the causes of accumulation of the fluid.

(l)   Rachitis (or Rickets): the frontal bone has a remarkable appearance: it is unusually prominent in its upper portion: the term used by French writers is "bombé."

(m)   Other bone diseases produce characteristic deformations. Among these Congenital Syphilis, Leontiasis ossea, and Acromegaly are perhaps the most important.

A map (cf. Fig. 180) is appended to show the distribution of the practice of artificial cranial deformation geographically.

Fig. 180.   The horizontal shading marks the geographical distribution of the practice of artificial deformation of the skull.   The Malay Peninsula should be so marked in addition to the other regions[2].

[1] It was probably in such a specimen that the great number (172) of wormian bones were found, as recorded by Charles A. Parker.   Cf. Bolk, *Petrus Camper*, Di. II. Afl. 2.

[2] Cf. Annandale, *Fascic. Malay*: 1904.

IV. Posthumous deformation is due to the action of the medium in which a corpse has been interred. Perhaps the most common effect is the production of plagiocephalus, owing to pressure being exerted unevenly on the skull. Besides this, every degree of flattening in almost any plane, may be produced. These conditions are usually distinguishable from other varieties of deformation by the facts that the skull is commonly excessively fragile, and can rarely be removed intact from the surrounding earth: moreover the cranial sutures will not be closed by synostosis, except in senile specimens whose age would be indicated by other characters such as those of the mandible and dentition.

CHAPTER XI.

THE CRANIAL INDICES, ANGLES, AND CAPACITY.

In the preceding chapter a scheme for drawing up a cranio-logical description was set forth, and to this was appended a list of measurements which prove of use in enabling comparisons to be made more exact than by the method of inspection alone. It was pointed out incidentally that certain writers disregard, to a large extent, the numerical craniometrical method. The other extreme has been reached by such observers as v. Török[1] in Buda-Pesth, and Benedikt[2] in Vienna, in whose contributions to craniology measurements are detailed in vast numbers. The question at issue is a fundamental one, and involves the view taken of the nature of such an organic structure as the cranium considered as a whole; that is, whether it is justifiable to apply to its study similar methods to those in vogue with regard to such bodies, for instance, as possess crystalline form. The point of view here submitted as most reasonable regards measurements as of unquestionable utility, and it is incontrovertible that if measurements are made at all, no pains are too great to bestow on the method by which they may be made in a strictly accurate and comparable fashion. At the same time, when the subject is approached from the point of view of morphology, and not from that of the science of statistics, one finds that comparatively few measurements have been so employed as to provide general conclusions applicable to the wide range of forms under observation, and for this reason it is believed advisable

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[1] v. Török, *Grundzüge einer systematischen Craniologie*, Stuttgart, 1890.

[2] Benedikt, *Manuel technique et pratique d'Anthropométrie cranio-céphalique*, Paris, 1889.

(except in original researches the results of which may subse-
quently contribute to the progress of science), to limit the number
of measurements to the small number which appears in the list
provided in the last chapter.

When numerical data have been collected, the next natural
step is a direct comparison of the corresponding figures relating
to different examples, and the methods of making such comparisons
are found to be numerous. Before proceeding to the consideration
of these it will be well to complete that part of our subject which
bears upon measurements, and to review the more important
measurements to be made upon other parts of the skeleton than
the skull and also upon the soft tissues and the external form. In
the present connection, therefore, the next subject for consideration
is that of the method of indices, which consists in the comparison
of different dimensions of the same specimen, and the closely-allied
method of moduli.

Indices. The fundamental idea in the construction of an index
is that a single numerical expression shall be so devised as to
yield an "indication" of the proportion or relation obtaining
between certain quantities, and in the present subject those
quantities are commonly limited in number to two. The simplest
index is then the fractional value of the arithmetical proportion of
the two quantities; for example, we may suppose that the breadth
of the cranial part of a skull is to its length as 3 : 4 ; the index of
length and breadth will then be $\frac{3}{4}$ or ·75. Such an index is called
the breadth index of a skull, and conventionally it is usual to
express it not as the direct, but as what may be called the per-
centage proportion, so that in the foregoing instance the index
would be ·75 × 100 or 75, and the index would for similar instances
be derived from the formula $I = \frac{B}{L} \times 100$. The number 75 thus
imparts an idea of the proportions of maximum breadth and
maximum length of the specimen, which may then be in this
manner clearly contrasted with, for instance, a second skull having
as index the number 90. Moreover, we must not forget that the
indication is one of proportion only, and that in the two instances
quoted, the actual value of one of the two dimensions compared
by means of the index might be identical in the two skulls, and

that the difference in the indices would be then due to the difference obtaining in the other dimension. In the next place it will be remarked that the quantities compared are rectilinear measurements of breadth and length, measurements approximately in the same plane: but it is not necessary that the quantities compared should be of the same kind though it is advisable that this should be so: for instance, an index might be obtained from the proportion borne by the number representing the weight of the skull to the figure representing its length, or to that representing its circumference or its cubic capacity: or the proportion of the weight of the brain to the stature of an individual might be expressed as an index: nor is it necessary as indeed follows from the last sentence, that the measurements should be made in one plane; for an index may represent the relation of height to length (or breadth) of a skull, just as it has been shewn to be capable of expressing the proportion of breadth to length.

The indices in common use may now be enumerated as follows :—

1. The Cephalic or Breadth Index, by which cranial breadth and length are compared.

2. The Altitudinal or Height Index, by which cranial height and length are compared.

3. The Alveolar Index, by which the lines from basion to nasion, and to prosthion respectively, are compared.

4. The Nasal Index, whereby the width and the height of the nose[1] are expressed.

5. The Facial Index, by which the height and breadth of the facial part of the skull are compared.

6. The Stephano-zygomatic Index, by which the inter-stephanic and the bizygomatic diameters are compared.

Of other indices a great number have been used in craniometry, but only one will be here mentioned. The Orbital Index compares the height and width of the orbital aperture, but its range of variation is too great to render accurate information in most instances. So many records of this index exist, however, that at least it must be mentioned here. Lastly, and as regards the morphological value

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[1] The nasal aperture of the cranium.

of indices, it must be pointed out that historically the oldest is the Breadth Index, devised by Retzius for the purpose of expressing the proportion of breadth 'and length : but that it cannot be said that more than general morphological information is conveyed by this index. Flower, on the other hand, conceived the idea of referring all dimensions to one standard, selected on morphological grounds, and actually the length of the cranio-facial axis. In this scheme every cranial dimension might thus contribute to the formation of an index with a common denominator. As a matter of fact, we have retained but one. such index, the Alveolar, or Prosthionic Index, which, as will be seen on reference to its description, expresses the length of the basi-prosthionic, in terms of the basi-nasal line, the latter being representative of the cranio-facial axis. In the next place, we come to the consideration of classifications based upon the numerical values of indices. Our example contrasted skulls in which the indices of breadth and length were 75 and 90 respectively : crania are found to provide indices (of breadth and length) of any value from about 56 to 95, in specimens that are not artificially or pathologically distorted. So for the Height and other indices a considerable range of variation occurs. With regard to the Cephalic Index, it has been conventionally agreed to apply to skulls providing this index with a smaller value than 75, as dolicho-cephalic, for such skulls as possess a maximum transverse cranial diameter less than three-quarters of the maximum length give the appearance of elongation : should the figure be 75 or any higher figure up to and including 80, the designation of the example is mesati-cephalic (of mean proportions), and from 80·1 upwards the term applied is brachy-cephalic, the form then appearing short in comparison with the foregoing. Proceeding in this manner the following table may be drawn up, and a few words of explanation will next be added to each of the several indices : reference should also be made to the general description. (Cf. p. 232.)

Index	Classification	Nomenclature	General indication
1. Breadth: $\dfrac{\text{Maximum breadth} \times 100}{\text{Maximum length}}$	Below 75	Dolicho-cephalic	Variable, and dependent on Age, Sex, and Race.
	Between 75 and 80	Mesati-cephalic	
	Above 80	Brachy-cephalic	
2. Height: $\dfrac{\text{Basal height} \times 100}{\text{Maximum length}}$	Below 72	Tapeino-cephalic	In general, the lower the index, the lower the cranial form.
	Between 72 and 77	Metrio-cephalic	
	Above 77	Akro-cephalic	
3. Alveolar: $\dfrac{\text{Basion to prosthion} \times 100}{\text{Basion to nasion}}$	Below 98	Orthognathous	The greater the index, the greater is the projection of the jaw, and consequently the more ape-like is the countenance.
	Between 98 and 103	Mesognathous	
	Above 103	Prognathous	
4. Nasal: $\dfrac{\text{Nasal width} \times 100}{\text{Nasal height}}$	Below 48	Leptorrhine	Lower forms of crania have the greater indices.
	Between 48 and 53	Mesorrhine	
	Above 53	Platyrrhine	
5. Facial: $\dfrac{\text{Nasion to prosthion} \times 100}{\text{Bizygomatic breadth}}$	Below 50	Chamaeprosope	Generally the lower forms have the lower indices.
	Above 50	Leptoprosope	
6. Stephano-zygomatic: $\dfrac{\text{Inter-stephanic breadth} \times 100}{\text{Bizygomatic breadth}}$	Below 100	Phaenozygous	In the lower cranial forms the index is below 100.
	Above 100	Cryptozygous	
7. Orbital: $\dfrac{\text{Orbital height} \times 100}{\text{Orbital width}}$	Below 84	Microsemic	Indication variable: generally speaking, lower human forms have lower indices.
	Between 84 and 89	Mesosemic	
	Above 89	Megasemic	

The Breadth or Cephalic Index: the description and definition of this index have afforded a means of appreciation of the information which it yields. It is unfortunately not applicable to the crania of the Simiidae with results strictly comparable to those obtained from human skulls (for in the Simiidae bony ridges modify the form of the cranial bones to a very considerable degree); but there is a certain indication that the skulls of Orang-utans tend towards the brachy-cephalic class, those of Gorilla to the dolicho-cephalic category (and with the latter are associated many examples of the Cercopithecidae), while the Chimpanzee may be considered to represent the intermediate group. Thus, taken by itself, no absolute indication of morphological inferiority is provided by a low, moderate or high figure representative of the Breadth Index.

When the comparison is restricted to human crania, the results are a little clearer. The chief modifying influences may be summed up as dependent upon Age, Sex, and Race. The skull-form in the pre-natal (foetal) stages tends on the whole to brachy-cephaly (see Gönner: ref. Chapter VII. p. 162), and a comparison of Froriep's figures for this index in skulls of infants and adults in the Würtemberg collection points to the same conclusion. In regard to sex, a good example is that yielded by the almost extinct aborigines of South Africa, the Bush natives: the female skulls are here mesati-cephalic, the male crania are dolicho-cephalic on the average. Finally, there is no doubt that in the darkly coloured races (including human beings on the lowest known level of culture) the predominant form is dolicho-cephalic, though at the same time this character is again found among certain white stocks inferior to none in intellectual ability.

A table lately compiled by Deniker gives the following figures as representing the extremes of variation of the average cephalic index in human skulls:

> 73 Fijians: average cephalic or breadth index, 67·2
> 41 Lapps: „   „   „   „   „   85;

and lastly, that the increase in breadth of the skull, which is the prime cause of the production of the brachy-cephalic proportions, is due to general expansion of the cranial contents, has just been very ingeniously demonstrated by Professor Arthur Thomson, whose model (devised for this purpose) is described, and represented in a private publication (Clarendon Press, Oxford), as well as in the *Journal* of the Anthropological Institute.

The Altitudinal or Height Index. Considerations similar to those which apply to the last index also prevent the use of the Height Index as a means of accurate comparison of the skulls of Hominidae and the Simiidae. When we again restrict observation to the former, we find that, as a general rule, the Height Index varies with the Breadth Index directly, so that where the skull is very elongated, then the expectation would be to find a small figure representing the Height Index (with the corresponding denomination of tapeino-cephalic). This tendency is shewn by a study of Froriep's figures for the indices of crania in the Tübingen

collection: in children's crania, the average index is 75·2 ; with the increase in dolicho-cephaly as maturity is approached the height index falls in value, till in adults it averages 72·9. As regards the influence of sex no definite statement is possible, but in respect of racial influences, the elongated skulls of darkly pigmented races yield the best examples of this relation, for such it is, between the breadth and height of the cranium, but the tendency appears to be otherwise independent of race. Striking exceptions to this general statement occur among certain of the Oceanic negro races, in which the skull being often narrow, and at the same time vertically expanded, is described as hypsi-steno-cephalic in form. As extreme examples there may be quoted the figures given by Topinard, representing average values, though the number of observations in each case is not stated.

Pre-historic French (Caverne de l'Homme mort) : 68·8 : tapeino-cephalic.

Javanese: ....79 : akro-cephalic.

The Alveolar Index enables direct comparisons to be instituted between the skulls of various mammals. In this index the amount of projection of the maxilla beyond the cranial base is measured, by the comparison of the line drawn from the basion to the extreme anterior maxillary point (prosthion), with the line representing the cranio-facial axis. We may here confine our attention to the families Simiidae and Hominidae : and as examples of the value of the index, representative figures may be quoted (a) for the skulls of Gorilla[1], 139·7 [2] Orang-utan 155·3 [1] ; Chimpanzee 128·8 [1]. (b) for skulls of aboriginal natives of Australia the range is from about 96 to 108. Within the limits of the Hominidae, we have to consider first the influence of age ; and in this connection the following figures are illustrative.

(a) for new-born children (European): 93·5 [2] [2].

[1] The figures in brackets represent the number of examples whence the figures are drawn.

[2] The question of the prognathism of the infant at birth is a subject upon which diverse views are held (v. supra Chapter VII. p. 172). In point of fact, the teeth within the substance of the foetal and infantile maxilla so modify its form as to render comparison with the fully developed maxilla quite fallacious. The evidence of this index is however more reliable than that provided by the facial angle, and the foetal or infantile skull is essentially orthognathous.

(b) For adult Europeans (average from Flower's Catalogue[1]) 96·2 [184].

In the second place, the sexual factor has to be considered, but herein no important differences have been observed in the skulls of Europeans, though an indication is given of the more pronounced maxillary projection in female crania. This indication is more definite in the case of the aborigines of Australia, as evidenced by the following (average) values of this index;—aborigines of Australia, average for males 100·4 [73]; for females, 103·1 [83]. Thirdly, the influence of race must be taken into consideration, and the figures which follow illustrate the differences obtaining in different racial types. Examples of these may be given in this place. Ancient Egyptians (average quoted in Flower's Catalogue): 95 [22]. African negroes (average quoted in Flower's Catalogue): 104·4 [36].

The Nasal Index also affords a direct means of comparison of the skulls of various mammals. Again restricting ourselves to the Primate families Simiidae and Hominidae, the following data illustrate the character and value of this index in each case.

Nasal index in Simia, about 50.

Average nasal index in Man (British), 46.

Though the figure representing the index in the ape is higher, and the nasal aperture thus shewn to be wider relatively to its height than in Man, the comparison is not very exact, owing to the length of the nasal bones being reckoned in the height-measurement, and the absence of a nasal spine in the Simiidae. Factors are thus introduced which, although a comparison may be made, preclude accuracy. If, instead of the nasal index as defined, we consider the index of the aperture alone we find the following figures. Gorilla, 73: Europeans (Dutch), 63·7; herein the differences are further emphasized. But this index is not much more satisfactory than the ordinary nasal index, on account of the ambiguity in the indices of the apes consequent on the absence of the nasal spine.

Within the family Hominidae the influence of age must be taken into account: the value of the index in the new-born

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[1] Of the Museum of the Royal College of Surgeons in London. The figures in brackets represent the number of examples whence the figures are drawn.

(European) infant is about 62·9 [2], and this, compared with the figure quoted above for adults, shews the wider character of the infantile apertura pyriformis nasi.

When the influence of sex is considered, the following figures may be quoted: average European (German) male, 51·9 (Froriep); female (German, Froriep), 44·1. But as Topinard remarks (*El. d'Anth. gén.*, p. 293), the data are too conflicting to admit of a general statement.

Lastly, the influence of race is clearly shewn by the following results collected by Deniker.

Average value of the nasal index of the skull.

(*a*)   for Eskimo[1], 42·2 [46], (individual examples may yield figures as low as 32·7).

(*b*)   for South African negroes, 61·7 [15].

The Facial Index. By means of the facial index skulls are divisible into two groups, viz., narrow-faced (lepto-prosopic), and broad-faced (chamae-prosopic) types. The comparison with animals is unsatisfactory, owing to the modifications in facial length associated with prognathism and its converse, which may more than counterbalance variation in the bizygomatic breadth of the face. Making allowance for this, we note that the skull of an example of the Simiidae gives as the value of this index the figure 82·3, with which we may compare the figure 54, representative of English (Saxon) crania (Horton-Smith). The gap separating the Hominidae from the Simiidae is thus very distinct. Turning to the differences within the human family, the following data are illustrative: European males (*v. supra*), 54 [20]: females, 45·5 [2]. The latter figures are taken from Kollmann ("Bericht der XXIX allgemeinen Versammlung in Braunschweig," *Archiv für Anthropologie*: Correspondenz Blatt, S. 121). But though the female skull is generally narrower, the difference has not yet been worked out on an appropriate number of skulls. As regards the age-factor, the indices in two human foetuses at the end of intra-uterine existence are 39·3 and 39·4 respectively. These figures, compared with those for adults, are expressive of the small proportions of the face-breadth in the infant and foetus, just as the corresponding figures illustrate

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[1] The figures in brackets represent the number of examples whence the figures are drawn.

the limit of growth in facial breadth in the Hominidae as compared with the Simiidae. It will be remembered that this facial growth is expressed by the bizygomatic breadth, which is related to prognathism, and the mass of the temporal muscles.

Turning lastly to racial differences in this index, we may compare the average value for twenty European crania, viz. 54, with that of eight Australian aborigines, viz. 51, the latter figure one might have expected to be larger; and that this is not the case is due to prognathism, here associated with great facial elongation, without a corresponding degree of facial breadth. In the Eskimo cranium on the contrary, growth in breadth predominates, and the index is accordingly 55·9 (Assézat).

The Stephano-zygomatic Index (fronto-zygomatic index of Topinard) is not strictly determinate for other skulls than those of Hominidae. Within the limits of that family Topinard has worked out the results in reference to the modifying effects of age, sex, and race. With regard to these three factors, the following figures quoted by Topinard (*El. gén. d'A.* p. 936) are of interest. Europeans: infants (in the first six months) 116·2 : adult males (Dutch) 90·7 : adult females (Dutch) 94·6 : male aborigines of Fiji, 73·7. The respective influences of increase in age, of the male sex, and of the primitive nature of the race in contributing to the production of a small numerical value in this index, are thus most clearly shewn.

The Orbital Index. As regards the comparison of Hominidae with the other families of the Primates, it must be admitted that no satisfactory results have been arrived at: and even within the limits of the Hominidae, the range of variation of this index is so great that it has been accorded quite a subsidiary place in the list of selected indices. Among the Simiidae the form of the orbital aperture varies (cf. Fig. 52) with the genus; but while the difference in detail between the Orang-utan and the African Anthropomorphous apes is marked, the orbit is proportionately higher in all the Simiidae than in the Hominidae. Among the latter, the proportions of the orbit are much affected by the prominence and degree of development of the supra-orbital ridges: hence the influences of age, sex, and race must all be taken into

consideration.　As regards the former, dried skulls of foetuses and still-born infants often provide a paradoxical result; for instance the average index from two examples is 73·5, which is a far lower figure than would have been expected, and is to be attributed to some deformation having occurred during the desiccation of the specimens. With regard to the differences due to sex, Broca[1] has published figures to shew that this amounts to as much as 31 % of the total range of racial variation, as examples of which, there may be cited: Torres Straits Islanders: males, 83; females, 90.　The variations as regards race are from 98, which is the average value in ancient Peruvian (Aymara) crania, to 75·6, for aborigines of Tasmania. The high numerical value of this index among the yellow races, including Chinese, Polynesians, Javanese, Indians of North America, ancient Peruvians, and Eskimo, is remarkably constant.　The opposite extreme is provided by the dark-skinned races of Oceania. It thus appears that the vertical height of the orbit is proportionately great in the yellow-skinned races, and in females of whatever race. The white races occupy an intermediate place in this respect. The African negroes shew much variety, and the black races of Oceania, in whom the brow ridges are strongly developed, present proportions in which the vertical height appears diminished in contrast with the preceding examples.　As regards the crania of infants, and from the results of observation made in accordance with the German method, which differs but very slightly from that described in the text, the crania of infants possess on the average an orbital index (88·5) higher than that of the adult of either sex (85·5 for males, 86·4 for females)[2].

As regards the relation between the proportions of the orbital cavity and the range of human vision, the following note, taken from Seggel's work in v. Graefe's *Archiv* (XXXVI., Abth. II.), is of interest.　Stilling (Congress of Ophthalmologists, 1888) found myopia common in connection with a low (i.e. flattened) orbital aperture, and suggested that these proportions, together with the direction of the tendon of the superior oblique muscle and the pressure exercised by both oblique muscles, would cause antero-

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[1] Broca, *L'indice orbitaire*, Paris, 1876.

[2] Cf. Fröriep, Catalogue of the Tübingen Collection, *Archiv für Anthropologie*, 1902.

posterior elongation of the eyeball with consequent myopia. Opposed to this is the fact that in Esthonian scholars, who have broad faces and "low" orbits, the percentage of myopia is less than in Europeans in general (Pymsza, "Inaugural Dissertation" Dorpat, 1892).

In terminating the present chapter, a few remarks may be added on the subject of the classification of crania according to the evidence provided by the angular measurements defined in Chapter x., and of the cubical contents or capacity of the brain-case, with brief mention of some methods of classification dependent on observations on the weight of various bones, etc.

Angular measurements. As a means of estimating the projection of the maxilla, the angle known as the spheno-maxillary, as defined in the preceding chapter, is the most accurate of all the angles which may be described as facial angles. Hitherto, data relating to the value of this angle in various skulls have been insufficient to provide a detailed classification, but the following list shews how the Hominidae are by its means clearly differentiated from other Primates and Mammalia.

The Spheno-maxillary angle (measured on the mesial sagittal cranial section).

	Dog	(W.L.H.D.).	162°.
	Cercopithecus monkey	„	119°.
Simiidae	Simia (orang-utan)	„	146°. *
	Gorilla	„	125°.
	Chimpanzee	„	121°. (Cf. Fig. 181.)
Hominidae	Aboriginals of Australia (av. of 7)—92° 20′. (Cf. Fig. 182.) (W.L.H.D., Turner, et alii).		
	Europeans (av. of 2, W.L.H.D.).	75° 30′. (Cf. Fig. 183.)	

Huxley's figures (viz. 99° for a Melanesian, and 91° for a Tartar skull) are very closely but not absolutely comparable: for Huxley drew his anterior line through the akanthion, a less fixed point (morphologically) than the prosthion, which was that used in the foregoing measurements. The latter indicate that a gradual decrease occurs in the value of the spheno-maxillary angle in the evolution of the European cranial type. Huxley suggested a classification based on the slightly different maxillary angle measured by him, in which orthognathous crania, possessing an

angle of less than 95°, are distinguished from crania in which the
angle exceeds 95°, and which are to be called prognathous; and
the same writer records an example of a human skull in which the
value of this angle attained 110°.
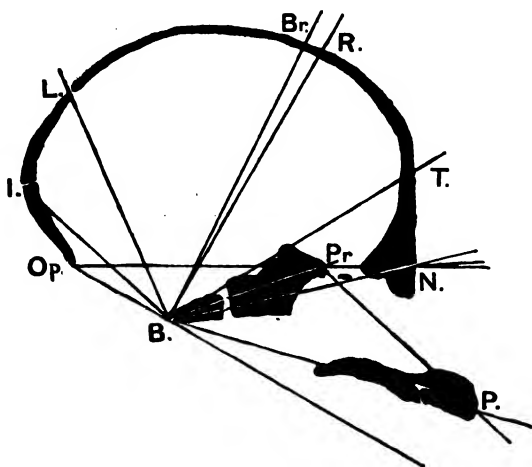
Fig. 181.   Tracing of the skull of a young Chimpanzee bisected in the median
sagittal plane (*Mus. Zool. Cant.*).   In this, and the two following illustrations the
following indications are provided.

Op : the opisthion.
B : the basion.
P : the prosthion.
N : the nasion.
Pr: the prosphenion.
T : the line tangential to the dorsum ephippii.
R : the line perpendicular to the plane of the foramen magnum (Op. B).
Br: the bregma.
L : the lambda.
I: the posterior occipital point.
The lines Pr. P. and B. P. include the spheno-maxillary angle Pr. P. B.
The lines Pr. B. and Pr. N. include the spheno-ethmoidal angle B. Pr. N.
The lines Op. B. and B. Pr. include the foramino-basal angle Op. B. Pr.
    With this and the two following figures should be compared, Figs. 4, and 74 to
81 inclusive.

The spheno-maxillary is thus by far the most important
angular measurement by which prognathism can be represented.
Owing however to the historical interest of the angle of Camper,
and the large number of data accessible for the angle of the
Frankfort agreement, a few words must be now devoted to their
further description.

Fig. 182. Tracing of the skull of an aboriginal native of Australia, bisected ir the median sagittal plane (*Mus. Anat. Cant.*). The indications are the same as nose in Fig. 181 (*q.v.*) with the following additions. G. the Glabella. W. the middle clinoid process (the latter point determines Welcker's angle).
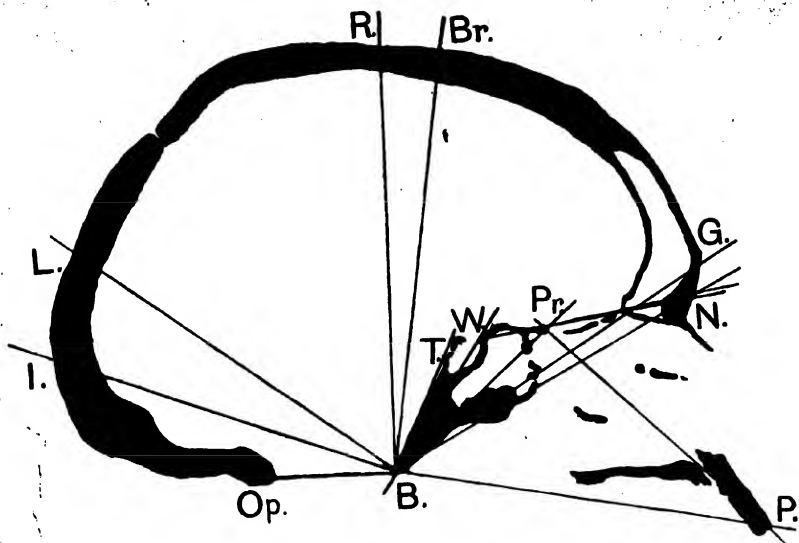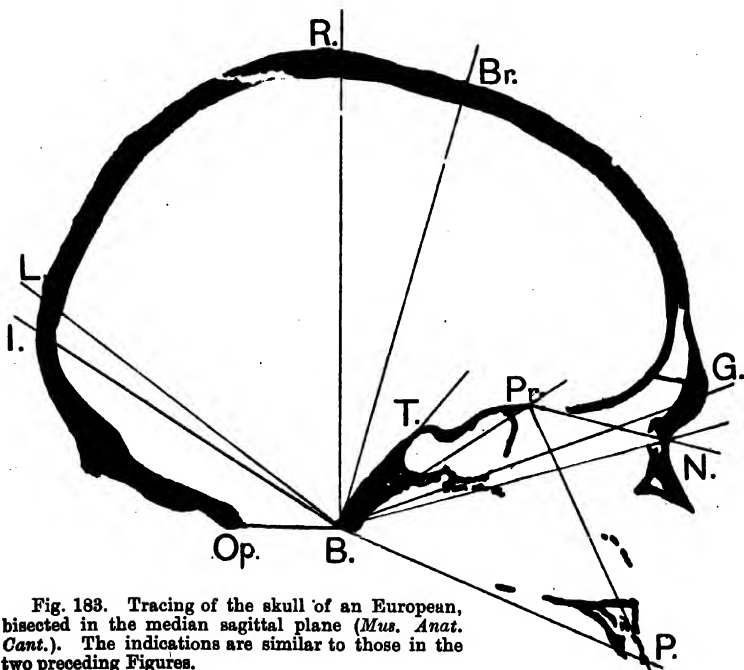

Fig. 183. Tracing of the skull of an European, bisected in the median sagittal plane (*Mus. Anat. Cant.*). The indications are similar to those in the two preceding Figures.

Camper's facial angle. No classification has been based upon the values provided by the angle of Camper in the Mammalia or within the family Hominidae. The following figures are taken as examples from Camper's original description.

In a small monkey (fam. Cercopithecidae) 42°.

In an adult Simia (orang-utan) 47°.

In a young Simia 58°.

In a negro 70°.

In a Calmuck 70°.

In a European 80°.

To this list Camper's remarks may be appended: "It follows from hence that the facial line has in nature a maximum and a minimum from 80 to 70 degrees (for Man). When the maximum of 80 degrees is exceeded by the facial line, it is formed by the rules of art alone; and when it does not rise to 70 degrees, the face begins to resemble some species of monkeys. ...If the projecting part of the forehead be made to exceed the 100th degree, the head becomes misshapen, and assumes the appearance of the hydrocephalus or watery head. It is very surprising that the artists of ancient Greece should have chosen precisely the maximum, while the best Roman artists have limited themselves to the 95th degree, which is not so pleasing....The two extremities therefore of the facial line are from 70 to 100 degrees, from the negro to the Grecian antique; make it under 70, and you describe an ourang or an ape: lessen it still more and you have the head of a dog." (*Op. cit.* p. 40. Cf. p. 244 *supra.*)

The Frankfort facial angle. The classification based upon the numerical value of the Frankfort angle is threefold; the three groups being as follows:—

The angle is less than 83°: prognathous[1].

The angle is between 83° and 90°: orthognathous.

The angle is above 90°: hyper-orthognathous.

As illustrative of the value of this angle in classification the Simiidae may be compared with the Hominidae.

The average value of the angle in a series of ten orang-utans

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[1] Care must be taken not to confound this with the terminology of the alveolar index (*v. supra*, p. 261).

was found to be 46° 6' (Waruschkin)[1], the corresponding figure for human crania being about 86° 9' (Froriep).

Within the Hominidae, the influence of age must first be taken into account. From the remarks (cf. footnote, p. 263) made in connexion with the alveolar index, it would be in accordance with expectation to find a large facial angle in the skulls of infants: and female crania should provide a smaller angle than male crania. Froriep's observations[2] fully bear out these expectations, for the figures provided are as follows.

Angle of the Frankfort agreement,

(a)   average value in infants and children up to 5½ years:—88° 30'.

(b)   average value in adult females:—85° 39'.

(c)   average value in adult males:—86° 9' (as above).

The Spheno-ethmoidal angle. The following list contains examples of the values of the spheno-ethmoidal angle as measured in a number of skulls.

	Dog	(W.L.H.D.).	231°.	
	Cercopithecus monkey	„	172°.	
Simiidae	⎧Simia	„	202°.	
	⎨Gorilla	„	158°.	
	⎩Chimpanzee	„	168°.	(Cf. Fig. 181.)
Hominidae	⎧Aboriginal Australians (av. of 2)	153°.	(Cf. Fig. 182.)	
	⎩Europeans (av. of 2), (W.L.H.D.)	138°.	(Cf. Fig. 183.)	

Huxley records 142° in a Tartar and also in a Melanesian skull.

The figures demonstrate the gradual diminution of the numerical value of the angle, and the consequent flexion of the cranio-facial axis as the human type is approached.

The Foramino-basal angle. For this angle the following figures were obtained:—

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[1] *Archiv für Anthrop.*, Bd. XXVI. "Ueber die Profilirung des Gesichtsschädels," p. 394: an Orang-utan skull at Cambridge provides an angle of 40°; Waruschkin (*op. cit.*) gives 58° 5' as the mean value from 4 crania of Gorilla, and 66° 7' as the value in a Chimpanzee skull: pp. 394, 397.

[2] Catalogue of the Tübingen collection, *Archiv für Anthropologie*, 1902.

	Dog	(W.L.H.D.)	108°.	
	Cercopithecus monkey	„	147°.	
Simiidae.	Simia	„	142°.	
	Gorilla	„	120°.	
	Chimpanzee	„	133°.	(Cf. Fig. 181.)
Hominidae.	Melanesian (1)	(Huxley)	147°.	
	Aboriginals of Australia(2)	(W.L.H.D.)	146°30'.	(Cf. Fig. 182.)
	Europeans av. (2)	„	149°30'.	(Cf. Fig. 183.)

The indication of the gradual opening of the angle, with consequent increase in its numerical value, is clearly shewn by inspection of the whole series, but the details of transition are not all so definitly indicated as in the case of the preceding angle. The foramino-basal angle is thus to be used in comparisons of the Hominidae and Simiidae with other families and other Orders, rather than for the comparative study of various members within the limits of those two families.

Cranial Capacity.   The cranial capacity of the smallest normal (adult) human individual is so superior to that of the largest member of the remaining families of the Primates that a comparison is hardly possible.   It seems as if 900 c.c. were the inferior limit of capacity (in adult Hominidae) compatible with normal mental development, and the highest figure on record for the capacity of the cranium of any other primate animal is 573 c.c. for an adult Gorilla[1].

Within the Hominidae, the influence of age is of course very evident, the cranium of the newly born child containing about 415 c.c. (Broca quoted by Topinard *El. gén. d'Anth.* p. 642), and at the age of three months 546 (Broca *loc. cit.*).   With these may be compared Broca's figures for adults in which the sexual factor is evident, viz.: for males 1559 and for females about 200 c.c. less.

Finally the racial factor is also distinct, and the range of variation is from an average capacity of about 1550 to 1600 c.c. (in the white and yellow races), to about 1250 c.c. in the dark-skinned Andamanese dwarfs.

The preceding remarks refer to determinations made with the use of shot, sand, or other material with which the skull

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[1] Quoted by Keith.   *Journ. Anat.* and *Phys. Jan.* 1895.

is filled, the contents being then poured out and measured. It is here appropriate to add a short account of the results of the investigations undertaken by Dr A. Lee (*Phil. Trans.* 196 A. 1901) with a view to the determination of the figure representing the capacity in cubic centimetres, from the values of three dimensions viz.: the length, breadth and height of the skull. In the first place, the combination of length, breadth and auricular height was found to give closer results than that of length and breadth with the basal height. Secondly, and this is in opposition to the view held by Boas ("The Cephalic Index." *The American Anthropologist*, Vol. I. N.S. 1899), the foregoing combinations are both preferable to the cephalic index, or the horizontal circumference of the skull for arriving at the closest approximation to the value of the cranial capacity. In the third place, while no less than nine formulae are provided, two in particular (Nos. 8 and 9, Lee, *op. cit.*) are recommended, and it is pointed out that theoretically it is in these determinations better to use one good formula, than to strike the mean of the results of several less accurate formulae. Of those specially recommended, No. 8 seems to provide the smaller probable error and is therefore given here; while No. 9 is appended as indicating the latest result of the use of the modulus derived from the multiplication together of length, breadth, and height. Moreover two other points must be noticed in connection with these formulae. In the first place, they are derived from data provided for German skulls, data for English crania not being available for the purposes of calculation: the formulae would therefore probably need slight modification for application to English or other crania, the modification being greater the less nearly the race was allied to the Germans. Secondly, different formulae apply to male and female crania, so that we find:

Formula (8). For German male crania

$$C^1 = 7\cdot384\ l. + 10\cdot898\ b. + 5\cdot228\ h. - 2094\cdot31.$$

For German female crania

$$C = 7\cdot065\ l. + 10\cdot126\ b. + 4\cdot828\ h. - 1902\cdot02,$$

and the second formula described may be appended, as follows:

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[1] C = capacity of skull in cubic centimeters.

Formula (9).   For German male crania

$$C = {\cdot}000332 \, (l. \times b. \times h.) + 415{\cdot}34.$$

For German female crania

$$C = {\cdot}000383 \, (l. \times b. \times h.) + 242{\cdot}19.$$

But as it is not unlikely that investigations may be directed to races not nearly allied to either the Germans, or to the Ainus for whom formulae have been published, Dr Lee gives a formula for general use, the accuracy of which will necessarily be less than when the German and Ainu formulae are used for Germans or Ainus, or for closely allied races respectively.   These general formulae are as follows:

Formula (10).   For males (negroes were excluded in calculating this formula)

$$C = {\cdot}000365 \, (l. \times b. \times h.) + 359{\cdot}34.$$

Formula (11).   For females (negroes were excluded in calculating this formula)

$$C = {\cdot}000375 \, (l. \times b. \times h.) + 296{\cdot}4.$$

Again where measurements of the heads of the living persons only are available, the closest approximation is arrived at by the use of Dr Lee's formula (14) viz.
for males,

$$C = {\cdot}000337 \, (l. - 11)(b. - 11)(h. - 11) + 406.01,$$

for females,

$$C = {\cdot}000400 \, (l. - 11)(b. - 11)(h. - 11) + 206{\cdot}6.$$

The remainder of the paper whence the foregoing extracts have been made, contains some most valuable results as regards the relation of capacity to brain weight.

Comparative weights of various parts of the skeleton. Recent researches by Messrs Manouvrier, Papillault and Mac Curdy have shewn that the weight of the skull only varies in a very general way, as for example with the total mass of the skeleton, and also with the amount of the cranial capacity.   (Cf. Mac Curdy, "Indices ponderaux du crâne." *Bull. de la Soc. d'Anth. de Paris,* 1897.)

With regard to the latter relation, the researches of Manouvrier

are very suggestive. The expression used as a means of comparison is the relation of the weight of the cranium to its capacity, the latter being considered as equal to 100. It will be noticed that this relation involves the comparison of two quantities (weight and volume) not strictly comparable. The results are however quite instructive. In the first place, the Simiidae and Hominidae are distinctly demarcated from one another. In Gorillas, the skull weight is represented by figures from 132 to 179·7, when the corresponding capacity is represented by 100. These figures (132, 179·7) may be called the cranio-cerebral indices, and we thus have

Gorilla:—132 to 179·7.

Man:—41·4 to 48·2.

Within the Simiidae the influence of age is marked as follows:

Young Chimpanzees:—60·4.

Adult Gorillas (v. supra):—132 to 179·7.

Within the Hominidae the same influence is shewn in the following way:—

New-born infants:—12.

Child of 3 years:—19·7.

Children of 7 to 15 years:—20·8 to 34·8.

Adults (v. supra):—41·4 to 48·2.

While the factor of sex is also influential, as shewn in the figures:—Males 41·4.   Females 40·1.

Turning now to considerations of race, we may note the following data.

Europeans (males): 41·4.   Females:—40·1.

Negroes (males): 46·4.   Females:—45·9.

The aborigines of Melanesia provide on the other hand a discrepant result[1].

Lastly, in all the foregoing instances allowance must be made for the factor of mass or bulk, as is indicated by the comparison of the indices in a giant: 64·2: and a dwarf: 44·1.

[1] Skulls in the Cambridge Museum give results as follows.
  (1) an Eskimo skull.   27·7 (1832).
  (2) a Polynesian skull. 38·9 (1814).
  (3) a Bushman skull.   44·1 (1744).
The Nos. in brackets are those of the Catalogue.

So that this index yields the following series in order of increase of weight in comparison with capacity:

Hominidae.
1. Infant.
2. Woman.
3. Man of small stature (or bulk).
4. Man of tall stature (or great bulk).
5. Primitive Man.
6. (Microcephalous Man—pathological).
7. Simiidae.

Interesting researches by Manouvrier also shew the relations between the weights of the skull and of the femora in different members of the Simiidae and Hominidae. Thus in the former, if the Gorilla be considered, the sum of femoral weights is to the cranial weight as 143 to 100 in males, and 107 to 100 in females. The former figures (143 and 107) may be called the cranio-femoral indices of these animals. Among the Hominidae, the influence of sex is predominant, and quite obscures those of age and race: this influence is shewn to be really due to the difference in bulk obtaining in the two sexes, and within the limits of either sex the same influence (of bulk) is felt. As examples, the following may be quoted. For males of various races, the cranio-femoral index is 123, for women 87. But to shew how important the factor of bulk is, the value of this index (132) in a giant may be contrasted with its value (49) in a dwarf. Within the two sexes finally, 81 % of men possess a cranio-femoral index greater than 100 (that is the femur is heavier than the skull in 81 %), whereas in women, only 17 % possess a femur which is heavier than their skull. The influence of bulk is again to be called in evidence, as responsible for these phenomena.

The capacity of the vertebral canal. The relation of the cranial capacity to the capacity of the vertebral canal is the subject of a paper by a distinguished anthropologist, Professor Johannes Ranke of Munich (cf. *Bastian's Festschrift*. Camb. Univ. Libr. MH. 32.4). The research shews that the proportion between the contents of the vertebral canal to those of the skull is not greater, *i.e.* is not more simian (or primitively eutherian) in the black than in the white races. Indeed the opposite relation would

almost seem to obtain.   Ranke rejects, as crude in conception, the comparison of brain weight and body weight as a test for the evolutionary status of Man, but it may well be doubted whether Ranke's substitution of the comparison of the respective capacities of vertebral canal and cranial cavity, is preferable to Dubois' improved method of comparing brain and body-weights, and then correcting for absolute bulk, species, etc.   (Cf. Dubois, "Über die Abhängigkeit des Hirngewichtes etc." *Archiv für Anthropologie*, Bd. xxv. Heft. 4; "Sur le rapport du poids de l'encephale etc." *Bull. de la Soc. d'A. de Paris.* T. 8; Sér. IV; Fas. 4, 1897.)

Among other points, Ranke notices the "progressive" condition obtaining in the new-born infant (but a warning must be entered against laying too great stress on the character in the new-born). Negroes, as has been remarked, occupy a position higher than white men.   Among the latter, males are "higher" than females, in contravention of Bischoff's assertion that the female brain is relatively greater than that of the male.   Lastly, among the Simiidae, and considering the Orang-utan (Simia) in particular, here, as among white Hominidae, males occupy a higher place than females.   Some of Ranke's figures are here appended.

Percentage value of the capacity of the vertebral canal; in terms of the cranial capacity; the lower the figure, the greater will be the preponderance of cerebral development.

I.   Hominidae.   A.   White races.   '
New-born infant: 2·70.
Adult males (av. 2): 8·41.
Adult female: 9·21.
B.   Negro races.
Male (av. 4): 7·69.   (One was a dwarf individual, however).

II.   Simiidae.   Orang-utan.
Male (av. 2): 18·73.
Female (av. 2): 22·19.

III.   Sheep: 77.32.
Cow: 146·72.

· IV.   Crocodile: 720.

CHAPTER XII.

COMPARATIVE OSTEOLOGY.

FROM the cranium, we now pass to the other parts of the skeleton, considering next in order, as is natural, the vertebral column, of which the several regions will be reviewed in sequence.

The distinctive features of the cervical spinous processes in the Gorilla have already been pointed out: in the whole range of variety in the human races, no approach is seen to the elongation of these spines so marked in Gorilla. The only approximation to the simian condition to be noted, is the lack of bifurcation said to characterize the lower races. The only other anomalies at all common in this region are (1) the fusion of two vertebrae, or of the atlas and occipital bone, and (2) the presence of cervical ribs. There is not sufficient evidence to associate either of these characters with definite morphological types, though either feature may be paralleled among the lower Eutheria and Vertebrata. The mention of cervical ribs suggests the commonest anomaly of the thoracic region (which is, on the whole, remarkably free from variation), viz.: the presence of an abnormal number of rib-bearing vertebrae[1].

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[1] While not productive of definite evidence to the effect that human types can be differentiated from one another on the basis of the number of vertebrae they present, the general question of numerical variations in the various regions of the vertebral column is so important as to demand a few words of comment in this place. We must first pass to the lumbar region, at the caudal end of which occur the most frequent anomalies affecting the numerical formula of the vertebral column, and particularly consider the evidence drawn from the study of such variations. This is the more important, as views are still current, against which most definite statements based on observation have been brought.

. Numerical variations in the several regions of the vertebral column cannot thus be applied to the classification we have here

We refer, in fact, to the theory advanced by Rosenberg as to progressive shortening of the vertebral column, a process described by that author as normally ontogenetic, a theory based on evidence shewn by the (alleged) precocious attachment of the 26th vertebra to the pelvic girdle ; this, it was believed, subsequently moves head-wards, incorporating the 25th vertebra, viz. the normal first sacral : the common anomaly of the partial or complete incorporation of the 24th vertebra being adduced as further evidence of the trend of evolution in this part of the skeletal system. The pelvic girdle is thus represented as capable of shifting along the line of the vertebral axis, and Rosenberg's theory explains the alleged shifting in the headward direction as the outcome of evolutionary changes, which (it is claimed) have been at work in the Simiidae ; in Hylobates equally with Man, in Gorilla and Chim-panzee more strongly, and most powerfully in Simia (cf. Cunningham, *Journal of Anatomy and Physiology*, XXIII. p. 7).

But another view is held, apparently due to Welcker, but of which the chief living exponent seems to be Professor Dwight of Harvard (cf. *Anat. Anzeiger*, Band XIX. s. 321), who (in a paper which I have found some trouble in understanding), explains his view, that the shifting is but a subsidiary cause of the variations ob-served, which he attributes to irregularity in the number of segments into which the pre-sacral part of the vertebral column is cut up : the number varying from twenty-three to twenty-six in a collection of vertebral columns examined by him. Dwight is thus thrown back on the explanation of irregular segmentation, as deter-mining the numerical variations in the vertebral column, whether in the lumbar, or sacral, or other regions ; of this irregularity he does not clearly provide an explana-tion, nor perhaps can it be provided at all in the present state of our knowledge of the nature and causation of variations.

Such then are the two views. It would be inappropriate here to set forth the arguments on one side or the other. Much more to the point however are the results of Professor Paterson's exhaustive researches (*The Human Sacrum*, 1893). These shew that Rosenberg is probably quite in error in generalizing to the effect that reduction in the lumbo-sacral region is occurring in Man ; for they shew that the balance of evidence strongly controverts Rosenberg's view, and that whether the explanation is to be found in a shifting of the pelvic girdle (which would be however tailwards, not headwards as suggested by Rosenberg), or in an appeal to irregular segmentation · (with Dwight), the tendency in Man is to elongation. No less important is Paterson's discovery and demonstration that the tendency of nerve-plexuses is to the incorporation, not of pre-axial but of post-axial nerves, so that Rosenberg's view is here controverted. In the third place, it is by no means sure that in development the second sacral vertebra is apprehended before the first, and in fact Holl (quoted by Paterson and Dwight *op. cit.*) gives directly contradictory evidence. These points have been here specially dealt with, because, even at the present time, Paterson's work (of ten years ago), has not received the attention it deserves : and in view of that work one must, perhaps regretfully, renounce the belief in what appeared a reasonable forecast of future human development, possessing the additional advantage of being in accord with the principles of

in view, and we must continue our study of that portion of the skeleton with respect to other descriptive features.

The portions of the vertebral column which have furnished the greatest amount of material for osteometry are the lumbar and the sacral regions.

A. The Lumbar vertebrae. Measurements have been made upon the lumbar portion of the vertebral column. They have been chiefly undertaken with a view to recording and comparing the varieties in curvature presented in various forms, and the following methods have been employed.

1. *Measurements made upon the skeleton.* It must be clearly stated at the outset that the results obtainable from measurement of the hard skeletal parts of the lumbar region are subject to very considerable modification, when reviewed in the light of the information provided by examination of the recent spine, in which the intervertebral discs are still present. Though this circumstance modifies, it does not destroy the value of researches carried out on the bones alone; we must also remark that in many cases of primitive and nearly extinct races, it is almost impossible that the recent spines will be available,

evolution.   From this point of view, Professor Cunningham's dissent from Professor Paterson's conclusions as to the bearing of his observations upon human evolution needs strengthening.   The recent work of Keith (*Journ. Anat. and Physiol.* xxxvii. p. 18.) shews that from the phylogenetic point of view, and comparing the Simiidae and Hominidae collectively with the Cercopithecidae, the evidence favours Rosenberg's hypothesis : nevertheless the difficulties are not altogether overcome : thus Simia with twenty-three pre-sacral vertebrae has too few vertebrae in the sacrum (4·7 on the average when 6 would be expected), and as regards the Hominidae, Bardeen and Eltung (*Anat. Anzeiger*, xix. p. 217), note in negroes a slightly greater tendency to distal displacement of the sacrum than in white men.   Keith admits the tendency, but suggests its greater distinctness in the negro as evidence that the tendency is apparent, and not real.   It does not seem necessary to adopt this view, for there is no reason why in one such respect the negro should not be in advance of the white as regards specialisation, which, in this instance, is in the direction of distal displacement of the sacrum.   Finally, as Keith deals primarily with the comparison of the apes and man, one can hardly expect to find exhaustive criticism of results of observations directed primarily to human examples.   But it does not yet seem as though the results of Paterson's work had been given due weight in these later publications.

whereas the several component bones in sequence are comparatively easily obtained. The same consideration applies equally to prehistoric human skeleton and to fossilised or semi-fossilised remains in general.

The vertical diameters of the centra of the lumbar vertebrae may be measured, and the anterior (median) vertical diameter compared with the corresponding posterior vertical dimension (cf. Fig. 184, A): an index of height may be constructed expressive of the value of the posterior measurement in terms of the anterior height taken as = 100, the index thus being derived from the formula

Index

$$= \frac{\text{posterior height of centrum} \times 100}{\text{anterior height of centrum}} :$$

should this index be less than 100, the vertebral body will be wedge-shaped, with the base of the wedge situated anteriorly, and the tendency will be to the production of a lumbar curvature anteriorly convex. On the contrary, the index may exceed 100, in which case the tendency is to the production of a concavity instead of a convexity forwards: or the intermediate upright condition may obtain.

We may now attempt a brief analysis of the results obtained from such measurements, comparing in the first instance the Hominidae with the Simiidae. (Cf. *Cunningham Memoir*, II. p. 5.)

A review of the measurements shews that both in the Simiidae and Hominidae the proportions of the uppermost lumbar vertebra are such that the posterior central height exceeds the anterior (the vertebral centrum is therefore wedge-shaped, the base of the wedge being posterior and the vertebra entering into the concavity of the thoracic curve). Secondly, when the lowest vertebra is
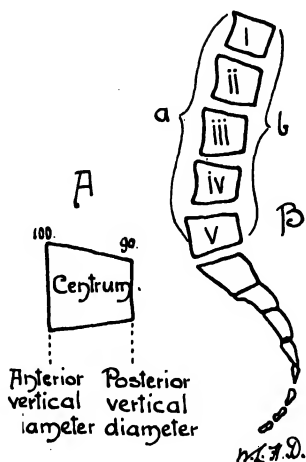
Fig. 184. *A*. represents the centrum of a lumbar vertebra: the "anterior vertical diameter" exceeds the "posterior vertical diameter." *B*. is added to indicate the manner in which the sum of the anterior vertical diameters may be compared with that of the posterior vertical diameters.

examined, it possesses, in the Simiidae, proportions similar in kind but less in degree, to those of the uppermost vertebra; i.e. the centrum is wedge-shaped, with the base directed posteriorly, but base is less wide than in the first lumbar vertebra. In the Hominidae (and also it is interesting to note in the Cercopithecidae[1]), the same diminution in the base line of the wedge occurs much more rapidly, so that the lowest lumbar vertebra has the exactly opposite character, i.e. it is wedge-shaped with the base anterior.

From these considerations, it follows that in comparing vertebral columns within the limits of the Hominidae, the retention of the upper lumbar type in the lower vertebrae of that series is a simian (but not a cercopithecoid) feature. Within the Hominidae, we must next consider the influences of age, sex, and race. With regard to age, we are chiefly dependent upon the data provided by Ravenel (cited in the sequel), which shew that in the infant at birth, the anterior and posterior diameters are equal throughout the lumbar series, a plainly simian feature; and though it is not clearly stated, there is in Ravenel's work an indication that the distinctive features appear in correlation with the assumption (by the infant) of the erect attitude.

Measurements made by Cunningham on male and female skeletons respectively (Table R, *op. cit.*, *v.* p. 282 *supra*), shew plainly that (1) the posterior height does not exceed the anterior in the uppermost vertebra by so much in woman as in man, (2) that the transition occurs higher in the series, from which it is argued that the characteristic human (as contrasted with the simian) feature is more pronounced in the female sex.

Turning to the racial influence, it appears from Cunningham's table (A) (*op. cit.*) that certain races (to which a lowly status has already, from other considerations, been assigned), are in respect of these proportions distinctly approximated to the Simiidae,

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[1] The unreliability of inferences drawn from the proportions of the lumbar centra, as to the attitude, whether erect or prone, of a given animal is hereby emphasized: this is of special importance when the evidence of fossil bones is under investigation. The number of lumbar vertebrae is well-known to be variable, but it cannot be said that any particular human race approximates especially to the Simiidae, in the manifestation of a tendency to reduce the number from five to three. A similar remark, mutatis mutandis, as regards the number of vertebral elements concerned, applies to the sacrum.

holding a place intermediate between these and the white race. The particular races mentioned are as follows: Australian and Tasmanian aborigines, Andamanese, Bushmen, and Negroes.

A somewhat less elaborate analysis of the character of the lumbar curve is obtained by constructing the lumbar index in such a way that the united heights of the centra measured posteriorly (cf. Fig. 184, B), should the sum of the posterior measurements be less than that of the anterior measurements, the indication is that of a forward convexity: should the sum of the posterior measurements be in excess, the convexity forwards is replaced by a concavity: finally the sum of the posterior may equal that of the anterior measurements and the column would then be straight or vertical in this region. The modified lumbar index is thus derived from the formula

$$\text{Index} = \frac{\text{sum of posterior measurements} \times 100}{\text{sum of anterior measurements}},$$

it is known as the lumbo-vertebral index, and numerically its value fluctuates between about 84·8 and 106 (Turner): in considering this variation, it is found that the influences of age, sex and race all take effect. As regards age, the following data are given by Ravenel and Aeby (quoted by Cunningham, "The Lumbar curve in Man and Apes." *Cunningham Memoirs*, II. p. 73).

In the new-born infant, the height of the vertebrae is the same before as behind, the index thus being = 100, and the lumbar column straight.

In the infant at 3 months of age, the anterior diameter begins to predominate, and this increase becomes more marked as the infant begins to assume the erect attitude; the influence of the extension of the hip-joint is important in this connection (Cleland, 1863) and it is probable that the permanent proportions of the lumbar centra are not finally assumed till maturity in other respects has been attained (cf. Balandin, *Virchow's Archiv*, 1873, quoted by Cunningham). But exact numerical data are scanty.

With regard to sexual variations, Cunningham's figures for Europeans, and Dorsey's[1] for American races shew that this factor

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[1] Dorsey, *Bulletin of the Essex Institute*, Vol. XXVII., 1895.

is distinct, and that the lumbo-vertebral index has on the average a lower numerical value in females than in males, the indication being that of more marked anterior convexity, a condition further removed from that of the Simiidae than that which obtains in male skeletons.

The racial influence is the same as noted when the several vertebrae were considered (*v. supra*, p. 284).

From the observations of Turner[1], the following classifications of races were drawn up according to the value of the lumbar index (or lumbo-vertebral index of Cunningham), and with Turner's data, those provided by Cunningham may be included here. Three categories are recognised, and the limits are drawn at 98 and 102, thus:

A.   The index is below 98 : Kurto-rachic class : the indication is of strong anterior convexity.   (Cf. Fig. 185.)

Europeans ⎱
Chinese   ⎰   (Group iv.[2])

Fig. 185.   Kurto-rachic type of lumbar conformation in the vertebral column : there is an anterior lumbar convexity.   This conformation is typical of the (adult) Hominidae.

Fig. 186.   Koilo-rachic type of lumbar conformation in the vertebral column : there is an anterior lumbar concavity.   This conformation is common in the Simiidae and Primates other than the Hominidae. In the foetal human being and some adult Hominidae, this type is however found to obtain.

Fig. 185. Fig. 186.

B.   The index is from 98 to 102 (inclusive) : Ortho-rachic class : the convexity is partially masked.

Eskimo.   (Group vi.)

.   Maori.   (Group i and Group v.)

To which Dorsey adds : Females of several American aboriginal races.

C.   The index is 102 or upwards : Koilo-rachic class : the

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[1] Turner, *Challenger Report*, Part II.   "Bones of the Human skeleton," pp. 72, 73.

[2] The Roman numerals refer to the morphological divisions of the Hominidae as described in Chapter xvi.

convexity is still less evident (cf. Fig. 186), or it may be replaced by a concavity.

> Polynesian (Oahu).　(Group v.)
> Andamanese.　(Group iii.)
> Negroes.　(Group ii.)
> Bushmen.　(Group vii.)
> Australian, with Tasmanian aborigines.　(Group i.)
> (*Simiidae.*)

To these Dorsey adds: Males of several American aboriginal races.

2.　The second method of investigation of the characters of the lumbar region involves the examination of spines in which vertebrae and intervertebral discs are still in natural apposition, and which have been sectionized mesially in the sagittal plane. In such preparations, measurements are made and compared as what is known by the name of "the Index of the lumbar curve" and this is computed in the following manner.

On the sectionized surface the following measurements are made. (Cf. Fig. 187.)

The line (AB), joining the mid-point of the upper surface of the first lumbar vertebra, with the mid-point of the lower surface of the last lumbar vertebra, is measured. On the section this line is drawn or marked by a rule or straightedge, and the maximum distance from it to the anterior surface, measured perpendicularly (CD), is observed. The proportion of CD to AB is then calculated, AB, the chord of the lumbar arc, being considered $= 100$. The index of the lumbar curve

$$= \frac{\text{perpendicular} \times 100}{\text{chord}}.$$
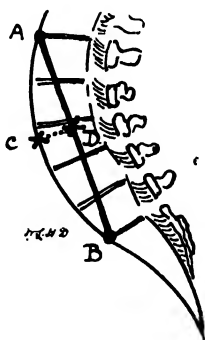
Fig. 187. Diagram representing the dimensions compared in the "index of the lumbar curve":

$A =$ mid-point of the upper anterior border of the centrum of the first lumbar vertebra.

$B =$ mid-point of the lower anterior border of the last lumbar centrum.

$AB =$ chord of the lumbar arc.

$CD =$ the longest perpendicular line from AB to the anterior margin of the lumbar curve.

Evidently the greater this figure, the more prominent will be the anterior lumbar curvature.

The variations of this character must now be reviewed; as regards the comparison of the Hominidae with other Primates, the following values have been obtained: (cf. *Cunningham Memoir II.*).

Cynocephalus porcarius.		(♂ juv.)	5·6.	(W.L.H.D.).
Orang-utan.		(♀ juv.)	4·1.	(Cunningham)
Chimpanzees.		(♂ juv.)	7·1.	(„)
„	(av.)	(♀ juv. 3)	9·3.	(„)
Men.	(av. of 7)		8·8.	(„)
Women.	(av. of 8)		9·5.	(„)
Boy.	(1)		4·1.	(Symington).

These figures shew practical identity between young Simiidae and adult Hominidae. (The figure for Cynocephalus is not strictly comparable with the others, for the animal has seven lumbar vertebrae). The indication afforded by measurements of the bones alone is thus very materially modified.

With regard to variations within the Hominidae, the influence of age is seen in the contrast of the index-value (4·1) in a boy, with the average figure for 7 men (8·8); the indication being that in the boy the lumbar curve is incompletely developed. Sexual differences are shewn by the figures for men (8·8), and women (9·5), indicating a greater anterior curvature in the latter; but with regard to race influence, it does not yet appear that data are available for comparison.

3.   As an indication of the racial differences in the curvature of the spine as a whole, there must be mentioned Cunningham's measurements upon living Bush natives (Hottentot-Bush men as Cunningham calls them) and Irishmen, of the dimensions which contribute to the formation of the index of " ensellure[1]." This index was constructed as follows: a tracing is made of the curves of the spine (by means of strips of lead moulded to the surface and then removed and traced): on this a line is drawn from the most prominent thoracic point to the most prominent sacral point (the prominence being directed in each case backwards): from

[1] *Cunningham Memoir* II.

this line a perpendicular is drawn to the point of maximum curvature in the lumbo-sacral ensellure, as in Fig. 188: the larger the index then, the deeper the curvature and the more prominent the anterior lumbar convexity. The Bush natives provided an average index of 7·2 (for 4 persons) while the average for two Irishmen was 4·3. This sufficiently expresses the exaggerated curvature in the Bushmen, to which appearance their gluteal development also contributes.

B. The Sacrum: the number of sacral bones is variable, and on this subject a note has already been made. The occurrence of the sacral notch is important: this is a simian feature due to the attenuation of the second sacral vertebra as compared with the first and third: in this way a notch is formed, opposite to the second vertebra, and bounded above by the first, and below by the third vertebra. Such a notch is common in Simiidae, rare in Europeans, and in

Fig. 188. AB joins the thoracic and sacral prominences: CD is the perpendicular the length x of the whole column being also measured and taken, as $= 100$ the index of enselline

$$CD \times 100$$

aborigines of Australia, but more frequent in Negroes and Andamanese (Negritoes)[1].

The following are the principal sacral measurements which have been studied:

(1) The length, measured from the mid-point on the anterior surface of the promontory, to the mid-point on the anterior surface of the lower border.

(2) The maximum breadth, measured across the alae.

(3) The depth of the curve, measured on the ventral surface or on a tracing, being the perpendicular distance from the line representing the length, to the deepest part of the curve.

(4) The length of the curve, measured on a flexible strip of metal, or on a tracing (such as may be made with a stereograph).

From the first two measurements a sacral index is derived, and the formula is: Index $= \dfrac{\text{Breadth of Sacrum} \times 100}{\text{Length of Sacrum}}$ on this a

[1] Paterson, *The Human Sacrum; Sc. Trans. Roy. Dublin Soc.*

three-fold classification is based, the demarcating numbers being 100 and 106, with a nomenclature as follows:

indices below 100: dolicho-hieric,
indices between 100 and 106: sub-platyhieric,
indices above 106: platyhieric.

In the comparison of the Simiidae with the Hominidae, the relative narrowness of the sacrum in the former, a character recognisable at a glance, is at once apparent when the sacral index is considered, for in two Chimpanzees Turner quotes an average of 77, in two Orang-utans an average of 87 (cf. Fig. 189), in a Gorilla 72, and a Gibbon 89, as against an average (male) human index of 112·4. The Simiidae are thus dolicho-hieric. The influence of age is discussed by Professor Thomson (*Journal of Anatomy and Physiology*, Vol. XXXIII., p. 372—3)[1]. As average values for four sacra of each sex in the foetus, he records for males 104, females 99·7, both practically within Turner's platyhieric class, or Paterson's sub-platyhieric class. Thomson insists rather too strongly upon the precocious attainment of the permanent adult

Fig. 189. Pelvis of an Orang-utan (Hose donation ii. Mus. Anat. Cant.); to shew the flattened iliac bones, the straight narrow sacrum, and transversely contracted pelvic brim.

proportions by the sacrum, and it seems as though the figures really suggest a slightly inferior status to that obtaining in the adult.

The influence of sex is shewn by Turner, who has compiled indices from his own measurements, combined with those of several other workers, which yield the following figures for Europeans: male 112·4, female 116·8; the female sacrum is thus evidently the broader. (In the foetal pelves the reverse condition obtains, and of this no explanation is forthcoming.)

Racial influences in determining the form of the sacrum cannot be overlooked. The classification based upon the numerical value of the sacral index results in the following divisions:

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[1] *v. supra*, Chapter VII., pp. 175, 176.

Nomenclature	Human race	The Roman numerals refer to the morphological divisions of the Hominidae as set forth in Chapter XVI.
I. Dolicho-hieric:		
Index below 100.	Bush race (with Hottentots).	Group VII.
	Bantu Negro.	Group II.
	Simiidae.	
II. Sub-platy-hieric:		
Index between 100 & 106.	Andamanese.	Group III.
	Australian (with Tasmanian).	Group I.
	Negro.	Group II.
	Chinese.	Group IV.

Also Ainu (contrary to Turner's surmise) and Japanese (cf. Koganei, *Das Becken der Aino und Japaner*, p. 34) men.

III. Platy-hieric:		
Index over 106.	N. & S. American.	
	with Peruvian.	Group IV.
	Eskimo.	Group VII.
	European and Lapp.	Group IV.
	Melanesian & Polynesian.	Groups I. & V.
	Hindoo.	Group IV.
	Guanche.	Group IV.
	Malay.	Group IV.
	Ancient Egyptian.	Group IV.
	Ainu women.	
	Japanese women.	

But the length-measurement of the sacrum is open to the objection that it does not express the degree of curvature of the bone, a curvature that is very marked in some cases. A numerical estimate of the degree of curvature may be obtained by comparing the length of the sacrum measured in accordance with the directions given on a preceding page, with the corresponding length measured along the ventral curved surface of the bone by means of a flexible measure. Though this method was suggested by Professor Cunningham at Glasgow in 1900, no data seem to have yet been published in illustration of the method. Another method is to measure the maximum depth of the curve by means of a perpendicular drawn from the line representing the direct length, to the deepest part of the curve: the average value of this line is 25·1 in the white, and 13·2 in the black race (Paterson).

The researches of Paterson[1] shew that the curve is deepest opposite the third sacral vertebra, and the curvature is greater below than above this point. It is not as a rule equal and uniform, but flattened above, and more distinctly curved below the third sacral vertebra (Paterson, *op. cit.*). In the Simiidae the curve is distinctly less than in the Hominidae, but the curve is similar in character to that obtaining in Man, i.e. the curve is more pronounced in the lower part of the bone. The several genera vary: the Gorilla and Orang are in this respect most closely allied to Man, for the greatest depth is represented by average figures of 10·4 mm. and 10·6 mm. respectively: in the Chimpanzee, the curvature is less, being represented by an average of 6·6 mm., and in Hylobates this is reduced to 3·1 mm., so that hardly any curvature can be said to exist. In the white Hominidae the average figure is 25·1. Within the Hominidae, age determines the degree of curvature which, though present from a very early period (e.g. in a foetus 46 mm. in length, and consequently about 3 months old) is not fully developed till the infant has attained the erect attitude: the difference between the Simiidae and the Hominidae depends on the same consideration.

As regards sex, the general conclusions quoted above from Paterson's memoir, are said by that author to apply equally to both sexes, though he adds that the female sacrum is more often curved more deeply in its upper part than the male sacrum. At the same time the actual amount of curvature is greater in the male sacrum irrespective of the absolute size of the sacrum.

C. The Pelvis. Apart from the proportions of length and breadth which will be considered under the heading of pelvimetry, the chief characteristics of the human pelvis are its compactness, the pronounced curvature of the ilia with the consequent production of iliac fossae, the development of the anterior inferior iliac spines, and the prominence of the ischial spines; on the iliopectineal line, the processes so frequent in the corresponding situation in the pelvis of Simia, are rare. Within the Hominidae, the sexual differences are perhaps the most striking, and while these and other differences such as those due to race, will be

[1] *The Human Sacrum.* Sc. Trans. Roy. Dublin Society.

further dealt with in connection with pelvimetry, the following remarks may here be made as bearing upon some descriptive points. The most recent and accurate contributions to this subject are those of Professor A. Thomson[1], and some of the conclusions arrived at by this author will now be given. We may notice then that the following sexual differences in pelvic form are distinguishable in human foetuses from the fourth month of pregnancy onwards.

(1) The parietes of the pelvis converge more rapidly from above downwards in the male, the pelvis being therefore more funnel-shaped in that sex.

(2) The ischia are more nearly approximate in the male, thereby narrowing the pelvic outlet.

(3) The iliac crests are less in-curved anteriorly in the male pelvis, contrary to the usual descriptions.

(4) The iliac crests reach a higher level and are more pronounced in the male pelvis.

(5) The great sacro-sciatic notch is narrower in the male pelvis.

(6) The sub-pubic angle is smaller in the male pelvis.

Of these characters, No. 3 is one in respect of which the Simiidae differ markedly from the Hominidae, and within the latter family, certain races (notably Group VII., *v. infra*) are distinguished from others on similar grounds. The last character, viz. No. 6, may be estimated by measurement and this brings us to the second part of the subject, viz. pelvimetry.

In comparing the human pelvis with those of the lower Primates, for instance one of the Cercopithecidae, or with most examples of the other Eutheria, a striking difference consists in the proportions of length and breadth of the pelvis as a whole: in the lowlier forms, the breadth is relatively smaller, and there is comparative elongation in a direction measured from the most anterior part of the iliac crest to the most posterior portion of the ischial tuberosity: in the human pelvis the breadth has increased with concurrent diminution in length. The Simiidae in these respects, are intermediate between the Cercopithecidae and the Hominidae. (Cf. Fig. 190; *A, B, C.*)

[1] *Journal of Anat. and Physiol.*, Vol. xxxiii., p. 59.
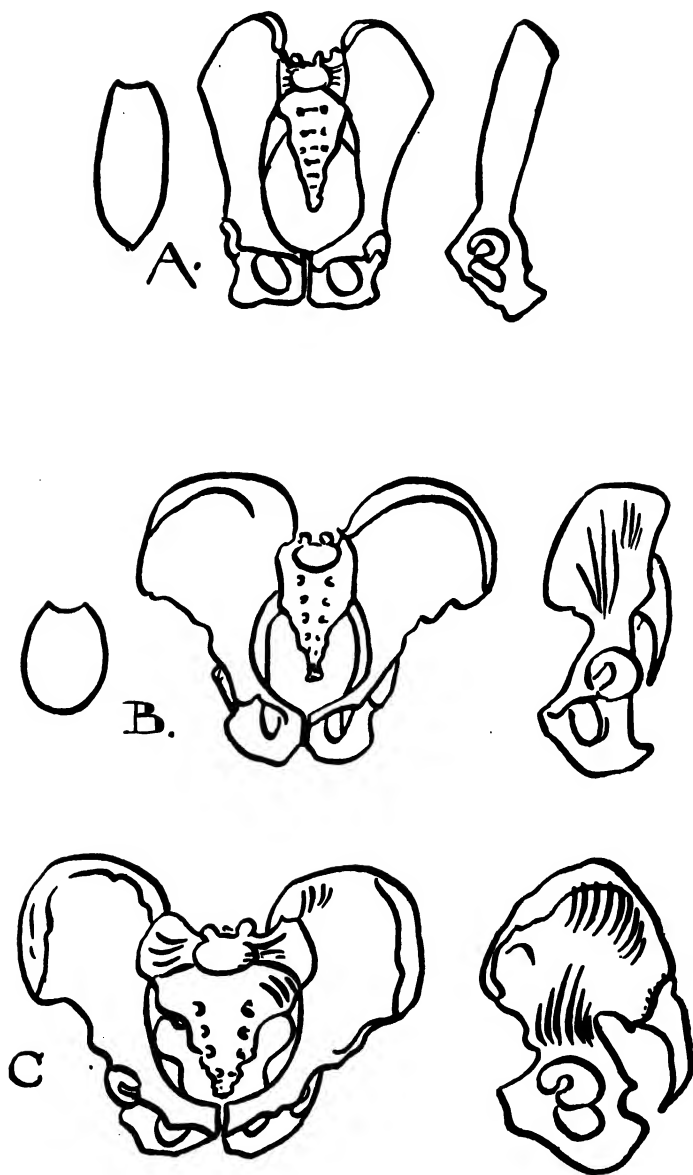
Fig. 190. The pelves of (A) Hylobates, (B) Gorilla, and (C) Man. The frontal and lateral aspects are shewn. The form of the brim of the true pelvis is indicated diagrammatically in A and B (to the left of these figures). (After Huxley.)

When the several constituents of the pelvic girdle are considered, and when the ossa innominata of the Hominidae and Cercopithecidae are compared, similar differences obtain to those just described; for in the Cercopithecidae, the os innominatum is narrow in the direction from its pre-axial to its post-axial border, whereas between these two margins the human os innominatum is broad: and again, measured from the iliac crest to the ischial tuber, the os innominatum of the Cercopithecidae is elongated in comparison with the stout shortened human bone. Some of the differences of detail which distinguish the os innominatum of Gorilla from the corresponding human bone are represented in Fig. 191.
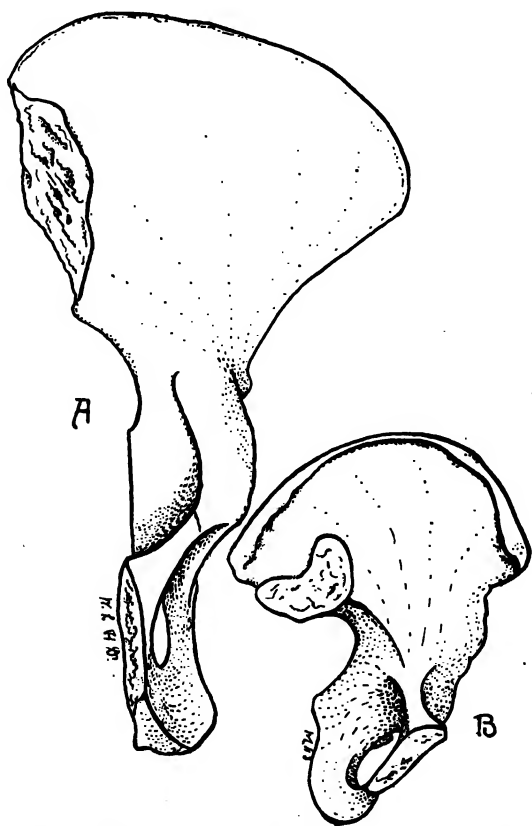
Fig. 191.   Left os innominatum (*A*) of Gorilla, (*B*) of Man.

These proportions have been expressed in the form of indices, and thus there are indices (1) for the whole pelvis, the pelvic index proper, not to be confused with the pelvic brim-index presently to be described, and (2) the index of the os innominatum.

The proportions of the pelvic brim are seen to differ markedly in the Cercopithecidae and most Eutheria, from those which obtain in the human pelvis. When the diameters, measured in the sagittal and transverse directions respectively, are compared, the former (the sagittal) will be found characteristically greater than the latter (transverse) in the lower Eutheria and Primates: this excess is reduced in the higher Primates, but in Man the reverse condition obtains. Comparing the two dimensions, the transverse diameter being taken as = 100, an index of the pelvic brim (often called the pelvic index, though quite distinct from the index of the pelvis as a whole), is obtained.

The general results of investigations upon these three indices may now be considered.

(I.) *The proportions of the pelvis as a whole.* The proportions of antero-posterior length (in Man, this dimension is called "height"), and transverse diameter (breadth) are compared by means of the pelvic index. Taking the latter diameter as = 100, the value of the former (antero-posterior length) has been calculated for various animals, and Topinard[1] gives the following list, here slightly modified in accordance with the definition of the index:

					Index
Metatheria:	Macropodidae	...	...	...	139
Eutheria:	Edentata...	...	...	...	138
	Rodentia...	...	...	...	133
	Carnivora	...	...	...	132
	Ungulata artiodactyla ...	...	...	123
	Primates. Lemuroidea...	...	...	144
	Cebidae	...	...	...	135
	Cercopithecidae	...	...	134
	Simiidae; Hylobates	...	...	121

[1] (a) *Revue d'Anthropologie*, 1874–5. (b) *L'Homme dans la Nature.*

Primates.   Simiidae; Av. of the three

	larger forms	...	87
"	Chimpanzee	...	97
"	Simia ...	...	83
"	Gorilla ...	...	79
(! Ungulata Perissodactyla	...	...	82)

To these may be appended the following figures from various sources[1]:

Hominidae: Average for white races   73

(Turner quotes variations from 74—79.)

Bush native ($\male$) (1) ...	...	...	91
Negro (4 $\male$)	...	...	80
" (2 $\female$) ...	...	...	73
European ($\male$)	...	...	79[2]
" ($\female$)	...	...	74[2]
Eskimo (1 $\male$) ...	...	...	77
" (1 $\female$) ...	...	...	77
Oceanic negro	...	...	77
Australian aboriginal (6 $\male$) ...	...	...	76·8
" " (1 $\female$) ..	...	...	76
Andamanese (2 $\male$) ...	...	...	76·5
" (3 $\female$) ...	...	...	76.
Aino ($\male$) ...	...	...	76·3[3]
" ($\female$) ...	...	...	72·9[3]
Japanese ($\male$) ...	...	...	74·6[3]
" ($\female$) ...	...	...	72·2[3]
Polynesian (5 $\male$) ...	...	...	72·3
European foetus (4 $\male$)	...	...	85·6
" " (4 $\female$)	...	...	82·4

From the foregoing list, it appears that the lower Eutherian mammals possess pelves of proportions very different from those

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[1] Turner, *Challenger Report*, Part II. *Bones of the Skeleton.*

[2] Verneau, quoted by Turner, *op. cit.*

[3] Koganei, *Das Becken der Aino und der Japaner.*

of the Hominidae, and that even the Order Primates alone provides a wide range of variety in this respect. Within the Order Primates, the proportions are seen to change progressively, in the sense of increase in pelvic breadth, from the Lemurs up to Man, the Simiidae in this, as in so many respects, being associated with the Hominidae rather than with the lower Primate forms. When comparisons are confined to the Hominidae, the influence of age is revealed by inspection of the index in the foetus and adult, and it is to be concluded, that judged by this test the foetus bears marked tokens of simian affinity.

When the sexes are compared, the female is seen to possess the human characteristic proportions in a more intensified degree than does the male, the latter being in this respect indeed comparatively simian.

When we turn to the data provided by various races, we find that certain of these are to be regarded as less removed from the Simiidae than are the white races. From the examination of the data available, and of the races investigated, the Bush race of South Africa seems to be particularly simian, and to nearly approach the Orang-utan in pelvic proportions.

With these remarks we may turn from the consideration of this index to the study of the proportions of the innominate bone.

From the foregoing remarks, it will be foreseen that the proportions of antero-posterior length (height, in the human skeleton) and dorsi-ventral diameter (breadth, in human anatomy) of the os innominatum, provide what is to a considerable extent a recapitulation of the foregoing results, so largely is the pelvic form dependent on the proportions of this constituent.

(II.) If an index of the innominate bone be constructed so as to compare its height, measured as in computing the preceding index, with the iliac breadth, measured from the anterior to the posterior superior iliac spine, and if it be arranged so that the index

$$= \frac{\text{iliac breadth} \times 100}{\text{innominate height}},$$ we shall find the following data:

Chimpanzee (1 juv. ? sex)	...	42·8 } (W.L.H.D. private coll.).
Gorilla (1 male ad.) ...	...	55·3 }
Human foetus (4 male)	...	67·6 (Thomson, *op. cit.*).

Human foetus (4 female) ...	69·7	(Thomson, *op. cit.*)
White race (adult males) ...	74·5	(Verneau, *Le bassin*, Paris 1875.)
„ „ („ females) ...	79·1	„ „ „
Australian aborigines (6 males)	79·6	(Turner, *Chall. R.* Pt. II.)
„ „ (1 female)	88·0	„ „ „ „
Negroes „ (3 males)	80·7	„ „ „ „
„ „ (2 females)	98·5	„ „ „ „
Bush native (1 male)	82·0	„ „ „ „
Polynesian Islanders (5 males)	88·0	„ „ „ „
Eskimo race (1 male)	89·0	„ „ „ „
„ „ (1 female) ...	87·0	„ „ „ „
Andamanese (2 males) ...	89·0	„ „ „ „
„ (2 females) ...	91·0	„ „ „ „

In this respect the Simiidae and Hominidae are clearly contrasted, the latter possessing the shorter broader ossa innominata; within the limits of the Hominidae, the indication is that the human character is acquired in the foetal stages, but is not then so pronounced as later, so that the foetus presents features intermediate between those of apes and adult human beings. In the comparison of the sexes, it will be noted that differences obtain even in foetal life, and that the female pelvis is characterized by the more pronounced development of the typical human proportions than is the male pelvis, the latter being thus inferior in point of evolution.

When we study the various data for the several human races, we find a most curious reversal of the order obtaining in regard to the breadth-height index just described, and the difference can only be explained by an appeal to the characters of the sacrum: the excess of sacral width in the white races being sufficient to cause the figure representative of their breadth-height pelvic index to exceed that for the other and darker races.

(III.) We come in the next place to the index of the pelvic brim, which is derived from the expression:

$$\text{index} = \frac{\text{antero-posterior diameter of the pelvic brim} \times 100}{\text{transverse diameter}}.$$

The latter dimension is measured from the posterior margin of the symphysis pubis to the promontory of the sacrum.

The following data are provided by Turner[1]:

In an Ox	the index is	110·0
Camel	,,	110·8
Chimpanzees (2)[2]	,,	133·0
Orang-utan (2)	,,	126·0
Gorilla (1)	,,	144·0
Hylobates (1)	,,	151·0

to which may be added

Hylobates (♂ 1)	,,	154·8	W. L. H. D. Mus. Anat. Cant.
,, (♀ 1)	,,	128·5	

Coming to the value of the index in adult European male pelves, we find that it rarely exceeds 90 (Turner, *op. cit.* p. 35).

The comparison of Hominidae with the other Eutheria mentioned, shews sufficiently plainly the diminution in the proportionate value of the conjugate diameter, which, as may be seen from the index-formula, is the variable quantity in the series.

Within the Hominidae, we have now, as in preceding cases, to consider the factor of age. Formerly, the foetal pelvis was believed to reproduce to some extent the lower Eutherian form, but Professor Thomson in his able paper already quoted, shews that this opinion must be revised, for the average index in four male foetuses of ages ranging from 4 to 7 months is only 86, and in four female foetuses of corresponding age, the figure is 83.

The latter statement reveals the influence of sex, which is thus seen to be active even at an early stage in development: it is still further emphasized in adults: and the difference will be observed to be one which relegates the male pelvis to a position nearer the Simiidae than the female human pelvis: a result which accords with the indications given by the two preceding indices of the pelvis.

The racial influence is seen most plainly in male pelves, for in no race does the average index for female pelves approach nearly to the figure for male pelves. Upon considerations of this index, Turner (*op. cit.*) has based the following classification: in all cases male pelves are dealt with.

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[1] *Challenger Reports*, Part II. *Bones of the Human Skeleton.*

[2] The figures in brackets indicate the number of individuals observed.

A.   Pelves in which the brim index is above 95—Dolicho-pellic:

>   Examples : Australians (I)[1].
>   Bush natives (VII).
>   Bantu negroes (II).
>   Andamanese (III),
>   and possibly Polynesians (V).

B.   Pelves in which the index is 95—90 inclusive—Mesati-pellic.

>   Negroes (II).
>   Tasmanians (I).
>   New Caledonians (I).

C.   Pelves in which the index is below 90—Platypellic.

>   White races (Eurasiatic including Ainö).
>   Yellow races (including Japanese)[2] (IV).
and probably Eskimo (VI).

In the foregoing classification, the dark races (Kaffirs, Bush and Australian), resume their position of closer approximation (than the white races), to the Simiidae, and from this and the other pelvic indices, the value of this part of the skeleton as a means of distinguishing morphological human types will be clearly understood.

The enquiries as to how far the form of the brim of the true pelvis affects the head of the infant at parturition, and how far such modification may in turn be related to heredity of head form are natural subjects for discussion in this connection.   The researches of Gönner[3] shew that as regards the modern Swiss (Basel), the general result of parturition, even in a brachycephalic population, is to modify the head form in the direction of dolicho-cephalic proportions[4].   Should the mother be brachycephalic, the infant will be also brachycephalic in 25 °/₀ of cases only : in only 18 °/₀ of cases is there concordance with the paternal form of head.   But if the presentation is of the breach variety, and in Caesarian sections,

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[1] Roman numerals denote human types as distinguished in chapter XVI.

[2] Koganei: *op. cit.* p. 19.   Cf. p. 296 *supra.*

[3] "Vererbung der Forme des Schädels," *Zeitschrift für Geburtshilfe und Gynackologie*, 1895, Band XXXIII.

[4] Cf. Chapter VII., p. 162.

the concordance is more frequent. But in any case, these re-searches shew no close correlation between parent and child. Nor is it very different as regards the size of the head, as tested by the measure of its circumference: when both parents have large heads, the child's head is in accord: but when only one parent has a large head, the infant's head is just as likely to be small as large and this is independent of which parent has the large and which has the small head, i.e. there is no pre-potency of either parent. The infant's head tends to become more brachycephalic in the first month of post-natal life, suggesting that the general result of parturition as mentioned above, is to impress dolicho-cephalic properties temporarily on the infant's head.

D. The Thorax. The human thorax in section presents a reniform appearance, the hilum corresponding to the depression along the vertebral column: the transverse diameter exceeding the antero-posterior diameter in a marked degree: similar propor-tions thus obtain to those observed in the pelvic brim (and it may be added, in the centra of the lumbar vertebrae). In the Simiidae the antero-posterior diameter is relatively increased, and in the pronograde Primates and lower Eutherian mammals, the section is almost elliptical, with the antero-posterior axis predominant, the exact converse in fact, of the human thorax. A thoracic index has been devised to illustrate the difference numerically. The antero-posterior diameter being taken as equal to 100, the index follows from the formula:

$$\text{index} = \frac{\text{antero-posterior diameter} \times 100}{\text{transverse diameter}}.$$

Weisgerber (quoted by Topinard, *El. gén. d'A.* p. 1051) gives the following average values, here modified in accordance with the formula quoted above:

16 Carnivora	...	131·6
64 Cercopithecidae		116·2
22 Cebidae	...	102·0
27 Simiidae	...	89·3
99 Men ...	...	85·4[1].

[1] Hovelacque and Hervé give 78 as the average for ten adult human examples.

A foetal thorax provides an index of 96·5 (W.L.H.D.).

While the distinctive position of the Hominidae is thus marked, and the intermediate or pithecoid condition is evident in the human foetus, the influences of sex and race are not yet clearly known: though Weisgerber's figures suggest that the female skeleton is more nearly simian than the male in this respect.

In the study of the skeleton we have thus noted the vertebral column (the lumbar and sacral parts being particular objects of attention), the pelvis, and the thorax, with special reference to the proportions of the latter. It may not be out of place to add here a note pointing out that the peculiar characters of the human skeleton as regards these features, are all concordant and dependent upon the one factor of the erect attitude: in relation with this are developed anterior lumbar convexity in a high degree, sacral width and curvature in a high degree, and increase in the transverse diameters of the pelvic brim and thorax, and these characters are largely due to the action of the body weight as carried in that particular attitude.

Pathology sometimes demonstrates the correctness of this statement and provides the experiment of softening the tissues so as to allow the weight additional opportunities for manifesting its effects. Thus in Rickets (cf. Fig. 193), the increased effect of weight is shewn by the exaggerated lumbar curve, the exaggerated sacral curvature, and the increased transverse diameter of the pelvic brim. Again in cases where disease has induced the bowed and bent attitude of spinal kyphosis (cf. Fig. 194), the lumbar curve diminishes, approximating to that of the simian form, the sacral curve is all but obliterated, and the antero-posterior pelvic diameter asserts itself, gaining in size upon the transverse diameter, which it may even surpass. Reduction in the transverse diameter of the brim is still more marked in the pelvis in which bilateral synostosis of the sacro-iliac articulations has occurred (Fig. 195, with which compare Fig. 192).

In spinal curvature consequent on caries, the lumbar curve may be increased and the thoracic proportions will be modified in the direction of further antero-posterior diminution in diameter. The effect of gravity in producing these results has been very cleverly demonstrated by Professor Dwight, who by adjusting

a circle of flexible steel ribbon (clock-spring) so that its plane is
either vertical (corresponding to the horizontal vertebral column of
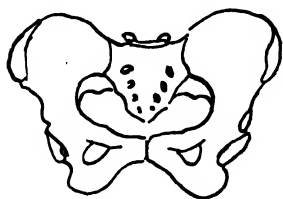
Fig. 192.

Fig. 193.
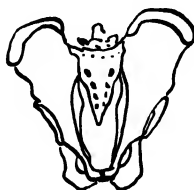
Fig. 194.

Fig. 195.

Figs. 192—195. The female pelvis. Fig. 192. The normal form. Fig. 193. The
pelvis in Rickets, with the brim widened laterally and compressed antero-posteriorly.
Fig. 194. The kyphotic pelvis, in which the transverse diameter is narrowed, and
the antero-posterior diameter increased. Fig. 195. The pelvis with bilateral syn-
ostosis of the sacro-iliac synchondroses. The transverse diameter is much diminished,
and the antero-posterior diameter correspondingly increased. This type (pelvis of
Robert) and the preceding (Fig. 194) should be compared with the simian pelves
shewn in Figs. 189 and 190 (*A* and *B*).

pronograde animals), or horizontal (as in the thorax of orthograde
animals), has shewn the differences in contour which the circle
assumes, and has pointed out that these correspond precisely to
those actually observable in the thoraces of pronograde and ortho-
grade mammalia respectively.

E. The anterior Limb-girdle. The modifications of the
clavicle according to age, sex, and race are not clearly known
and will accordingly be passed over in this place.

The scapula of Man differs from the generalized Eutherian
scapula in the great size of the acromion process, and in its
proportions, the scapular breadth, measured from the glenoid
margin to the vertebral border, being relatively small in Man.
Figs. 196 and 197 represent the differences which obtain in
these respects between the scapulae of a Rodent (rabbit) and Man

(Fig. 197). Intermediate stages are met with in the Simiidae, but strictly comparable measurements are very difficult to make, especially in the scapulae of the Orang-utan and Chimpanzee; indeed in many cases the reduction in breadth seems to the eye to have advanced to a further stage in these forms than in Man. The scapula of the Gorilla resembles that of Man more closely than those of the other forms mentioned, the acromion process being larger and consequently more human. Another interesting anatomical feature is the osseous process which is developed when the M. teres major is unusually massive: and another character that has been investigated is the angle included by the line of the scapular spine and that of the vertebral border. This angle (cf. Fig. 198) is more oblique in the Simiidae than in Man, and is related to the greater extent of the supraspinous fossa in the apes. The quantitative estimation of some of these characters may now be considered.

Fig. 196.   Right scapula of a Rabbit.

Fig. 197.   Right human scapula.

A.   The proportions of scapular breadth and length have been expressed by a scapular index

$$= \frac{\text{the breadth from glenoid margin to vertebral border} \times 100}{\text{the length from superior to inferior angle}},$$

(the denominator being considered = 100), and it must be repeated that the instructions for measurement, though well adapted to the human scapula, prove difficult of application to other scapulae, such as those of the Orang-utan (Simia). The following figures are given for this index by Broca (quoted by Hovelacque et Hervé: *Précis d'Anthropologie*, p. 103).

Carnivora	136—200
Cercopithecidae	110—144
[Hylobates	117·5 W. L. H. D. Mus. Anat. Cant.]
Hylobates	96·97
Simia	69·27

| Gorilla | 70·38 | ⎫ Livon, Flower and Garson |
| Anthropopithecus | 68·52 | ⎭ give similar figures. |

To which may be added

Central African Pygmy	87·9	(1[1])
Andamanese	70·2	(27[2])
Negroes	69·7	(100)
Polynesians	66·6	(32)
Bush	66·2	(10)
Europeans	65·3	(462)
Australians	64·9	(26)
Eskimo	61	(8)

From this table it appears that the Simiidae and Hominidae overlap to a considerable extent: while the former merge into the Cercopithecidae; nevertheless a considerable gap separates the three larger Simiidae from Hylobates, whose affinities are clearly with the Cercopithecidae in respect of this index. Of the Hominidae, while the variations are very great, the foetus (with a scapular index of 80 at the mid-term of pregnancy) is more simian than the adult man: sexual differences and lateral differences (i.e. between right and left scapulae) are obscure, and as regards racial influences the pygmy and black races evidently provide the most simian type.

B. The following figures are given by ‘Turner (*op. cit.*, p. 87) for the scapulo-spinal angle. (Cf. Fig. 198.)

Chimpanzee (av. of 4)	50°·5
Orang-utan (av. of 2)	66°·5
Aborigines of Australia (11)	78°·2
	(67° to 86°)
Europeans (25)	82°·5
	(73° to 91°)

So far then as the data go, it appears that the angle is greater in the Hominidae than in the Simiidae,
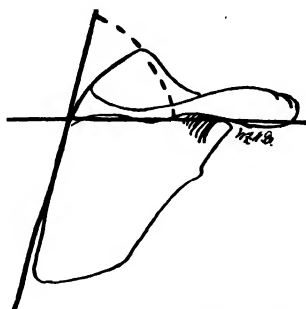
Fig. 198.   Diagram of a scapula, shewing the lines by which the scapulo-spinal angle is included.

[1] Shrubsall, in Johnston's *Uganda*, Vol. II.

[2] From Turner, *Challenger Report*, Part II. The figures in brackets give the number of observations in each case.

and that Australian aborigines are more simian in this respect than are Europeans.

F.   The Sternum.   The chief feature of importance in the sternum, considered in relation to the comparative morphology of the Hominidae, is the level at which the sutural line between pre- and meso-sternum persists (cf. Chapter IX.).   In the white races this level is commonly that of the second costal cartilage, but in aborigines of Australia the level of the third costal cartilage often marks the line of the persistent suture. Turner (*op. cit.*, cf. p. 305 *supra*), mentions a similar case in the sternum of an Andamanese Islander, and Keith has recorded the occurrence and noted its relative frequency in the Simiidae, pointing out its special frequency in Hylobates[1].   Thane[2] notes that the female sternum is relatively shorter (9.2% of stature) than the male (9.5% of stature), and that the proportions of pre- and meso-sternum differ in the two sexes.   The phenomenon of perforation of the meso-sternum seems to have a general morphological significance only.

[1] Keith, *Journ. Anat. and Physiol.*, Vol. xxx. p. 276 (1896).

[2] Quain's *Anatomy*, Vol. II. Part I., Osteology.   References to several papers are quoted.

CHAPTER XIII.

COMPARATIVE OSTEOLOGY (CONTINUED).

HAVING concluded the sketch of the morphological variations of the sternum, we have surveyed all parts of the skeleton, with the exception of the limbs, which accordingly now demand attention. A few descriptive remarks on each of the principal limb-bones will be followed by an account of the most instructive characters of the limbs hitherto established from researches in comparative racial morphology, viz. the differences observed in the proportional lengths of the two limbs and of their several segments. The number of characters considered is here strictly limited, as exhaustive accounts are accessible in various text-books on Human Anatomy. It will be convenient to consider first the upper limb, commencing with the humerus.

The Humerus. With regard to the general morphological characters of the humerus, and of such variations as may be ascribed to the factors so often enumerated in the preceding chapter, viz. position in the Natural Order Primates, Age, Sex, and Race, the evidence at hand is still comparatively scanty in amount.

A. Dealing first with the shaft, one may notice that in the Simiidae, more especially in Simia and Gorilla, the humeral diaphysis is very commonly more curved than the shaft of the human bone, and it is further interesting to notice that almost the exact converse statement applies to the femoral diaphysis in Simiidae and Hominidae. Thus the humeral shaft is curved (the concavity being directed anteriorly), the femoral shaft straight

in Simiidae, while the humeral shaft is straight, the femoral shaft curved (with the convexity directed forwards) in the Hominidae[1].

Hence a curved humeral diaphysis is to be regarded as a simian character. The same description will apply to humeri in which the external supracondylar line is so prominent as to form a flange-like projection from the shaft (this appearance is particularly common in the humeri of Gorillas).

B. The torsion of the humeral shaft has attracted a good deal of attention, for in its degree this character distinguishes the human humerus from those of quadrupedal mammals[2]. In the latter, the long axes of the upper and lower articular ends of the humerus are inclined at right angles approximately; Broca's measurements assigning a value of 94°·9 to the average angle among Carnivora. The same observer's figures for the average value of the angle in modern inhabitants of France is 164°; the degree of torsion here nearly amounting to two right angles. The range of human variation is overlapped by that of the Simiidae, whose close association with the Hominidae is thus once more indicated. And through the Primate series the numerical value of the angle gradually falls, till in the lowest forms it closely approximates to the average figure quoted for the angle in Carnivora. The following data (from Broca's research) are instructive. Average value of the angle of torsion:

Carnivora	94°·9
Lowest Primates	95°
Simiidae ; Hylobates	112°
„ Simia	120°·25
(Chimpanzee) A. niger	128°
„ A. gorilla	141°
Hominidae; Modern French	164°

[1] The comparison of the human humerus and femur with the corresponding bones of a Gibbon (Hylobates) will be found particularly instructive on this point.

[2] It may be remarked that no consensus of opinion appears to exist as to the exact nature of this torsion, nor as to which parts are affected and which are unaffected by the process, i.e. whether the shaft is unaffected and the torsion is produced only at the articular ends, or whether all parts are involved. No spiral fibres are seen in the structure of the bone, and as for the spiral course of the musculo-spiral nerve, it is such that it represents torsion in exactly the opposite direction to that which is described as having occurred. Besides, the other nerves shew no signs of a spiral course.

Within the Hominidae, the factors of age, sex, and race must be taken into account. As regards the former, Gegenbaur has established the occurrence of ontogenetic torsion amounting in all to about 35° in the course of development. Macalister (*Text-Book of Human Anatomy*) gives 30° as the value of the amount of ontogenetic torsion. No sexual difference has been noted[1].

Coming to the racial variations in torsion, we must again note the researches of Broca, which provide the following average figures.

Average value of the angle of torsion:

Aborigines of Australia	134°·5
Negroes	144°
Polynesians	144°
White race (average)	161°

C. The frequency of the occurrence of perforation of the olecranon fossa has been studied by various observers; normal in certain Eutherian orders, it is a variable character in others: in the Simiidae there is little doubt that it is more frequent than in the Hominidae: within the limits of the latter family its frequency seems to be associated with other differences of racial significance, but the indications still lack definition. With a per-centage of 4 to 5 in western Europeans may be contrasted the per-centages of 21·7 in African negroes, 34·3 in Polynesians, and 36·2 in the "Altaic" and American aboriginal races (Hervé and Hovelacque, *Précis*, p. 291). Moreover, the character seems to have been much more frequent in the prehistoric period, for the per-centage figure is 25·6 in the prehistoric Guanches of the Canary Islands; and in the pre-dynastic inhabitants of Egypt, Professor Macalister records the extraordinary figure of 60 % of perforated olecranon fossae. S. Hilaire found perforation of the fossa in the skeleton of the Bush-woman known as the "Hottentot Venus," dissected by Cuvier early in the 19th century.

D.   Obliquity of the forearm in extension.

A well-marked sexual difference is to be found in the relation of the long axis of the trochlear articular surface at the lower end of the humerus to the axis of the shaft. Macalister (*Human Anatomy*, p. 144) states that "the axis of the trochlea is oblique,

[1] Gegenbaur: *Jenaische Zeitsch. Bd.* IV. 1868.

cutting that of the humerus at an angle salient outwards of 105°
in the male, 108° in the female. Careful observation shews
(Fig. 199) that in the extended position, the axis of the forearm
is consequently not identical with that of the arm, but inclined
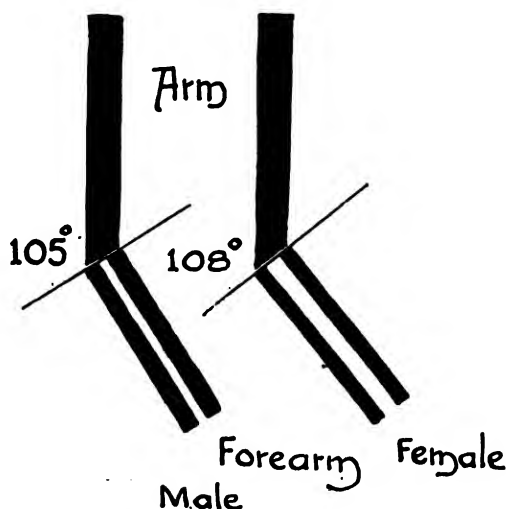
Fig. 199. Diagrams of the bones of the arm and forearm in (A) Man, and
(B) Woman: to shew the greater obliquity of the forearm in the latter sex.

out and downwards, the outward inclination being greater in the
female.   This character has also been investigated by Dr Potter[1],
who shews that the sexual difference in obliquity amounts on the
average to approximately 6°, the figures being as follows: for
males (95[2]) the deviation from the axis of the arm is 6°·8, and
for females (90[2]), the corresponding angle is 12°·65.   Moreover
Dr Potter describes the rectification that occurs in flexion, whereby
in the position of extreme flexion the axes of arm and forearm
coincide (in both sexes)[3].   It will be noticed that the statements
of Macalister and Potter are not quite concordant; for the angle

[1] *Journ. of Anat. and Phys.*, Vol. XXIX. p. 480.

[2] The figures in brackets denote the number of observations.

[3] In the lower extremity, a corresponding obliquity of the axis of the leg with
regard to that of the thigh constitutes the condition of "genu valgum" (knock-
knee).   In this condition the deformity presented in extension of the knee-joint
disappears when the leg is flexed upon the thigh (Potter, *op. cit.* p. 491).

of obliquity described by Potter ought to tally with the difference between the angle quoted by Macalister and a right angle (i.e. the difference of 105° and 90° = 15° for males, of 108° and 90° = 18° for females: Potter's results are as above, 6°·8 for males, 12°·65 for females). As Macalister's results are not accompanied by a statement as to the number of examples whence the generalisation is drawn, no final selection of the conflicting statements is at present possible[1].

Bones of the Forearm. Morphological variations associated with racial influences are very rare in the bones of the forearm. The occasional elongation of the styloid process of the ulna so as to produce an articulation between this process and the cuneiform bone of the carpus, suggests the fusion with the styloid process of a carpal ossicle belonging to the series described by Vesalius (os Vesalii) and others as sporadically occurring in this situation. (Cf. Forsyth-Major. "The Osteology of the Lagomorpha." *Linnaean Trans.* Vol. VII. Ser. 2, pp. 464 *et seq.*)

The interosseous space of the forearm is both absolutely and relatively larger in the larger Simiidae than in the Hominidae, the radius and ulna being distinctly bowed in the apes. Any approach to this condition would constitute a simian peculiarity should it occur in a human being, but the appearance is, so far as I know, a rare one: it is to be expected in the skeletons of aborigines of Tasmania, Australia, or the Andaman Islands, or in the Bush race of South Africa, and is present in the Neanderthal skeleton[2].

The Femur. A great number of anomalies of formation and development have been described in the femur. As in previous instances, only a very small selection will be noticed in this connection. (*A*) The curvature of the shaft of the femur has already been incidentally mentioned, and (*B*) the variations in the angle between the axes of the femoral neck and shaft have been briefly described in the section dealing with the anatomy of the

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[1] From the photographs published by Klaatsch, *Weltall und Menschheit*, Bd. II. p. 328, it is evident that the obliquity is much greater in the white than in the dark Hominidae: thus a racial difference exists in respect of this character.

[2] Cf. Chapter XVII.; also Schwalbe: *Der Neanderthalschädel.*

foetus. I cannot find evidence that either sexual or racial factors influence these characters; in fact, as regards the angle of the femoral neck, Rodet (quoted by Poirier) in a thesis on the femur (Paris 1884) concludes that the angle is the same in both sexes. Nor can any general statements as to sexual or racial differences be based on the degree of torsion of the femoral shaft (Bertaux, *L'Humerus et le Femur*, Lille, 1891, quoted by Poirier). Finally, though this is in some degree an anticipation of a future chapter, the characters of the femora of the prehistoric (fossil) skeletons known as those of Neanderthal and Spy (from the localities in which they were found), are to be remarked as quite exceptional. The chief peculiarities of these femora are the stoutness, the comparative shortness, and the pronounced curve, with anterior convexity of the shaft, with which is associated an unusually large head. With these may be contrasted on the one hand, the fossil femur of Pithecanthropus erectus (from Java), which more closely resembles the common form of modern human femur in its
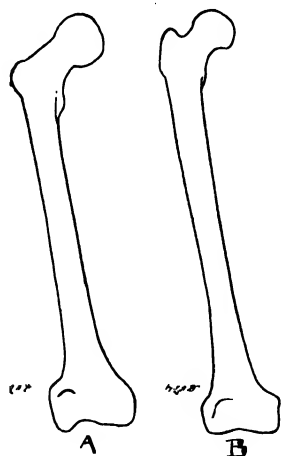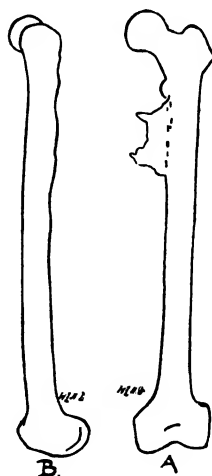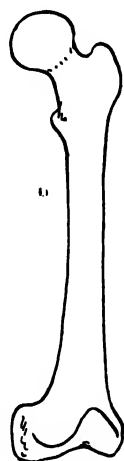
Fig. 200.   Fig. 201.   Fig. 202.

Fig. 200. Femora; (*A*) of H. neanderthalensis (Spy, No. 1): (*B*) of H. sapiens.

Fig. 201. Femur of Pithecanthropus erectus, (*A*) the anterior, (*B*) the external aspect.

Fig. 202. Femur of an Orang-utan (Hose donation II): this specimen is drawn to a larger scale than the bones represented in Figs. 200 and 201.

proportions, and the femora of the Simiidae, which are distinguished by the relatively small size of the head. The accompanying figures provide a comparison of the femora of H. neanderthalensis, of Pithecanthropus erectus, and of Simia satyrus. (Figs. 200, 201, 202.)

(*C*) The presence of the so-called third trochanter constitutes a striking femoral anomaly, but it must be pointed out that its occurrence has not yet been demonstrated in association with other racial differences: furthermore it is not a character approximating the Hominidae to any other family of the Primates: in fact to find this third trochanter well-developed and constantly present, one must pass to other Eutherian orders, and it will be discovered as a very strongly marked feature in that division of the Ungulata known as the Perissodactyla (or Ungulata with an uneven number of digits, such as the Tapir, Rhinoceros, and Horse), and it occurs again among the rodent Mammals.

(*D*) Extension of the condylar articular surface. Charles has directed attention to the great upward extension of the articular cartilage-clad surface on the posterior and upper aspect of the internal condyle occurring in certain skeletons. Such extension is by Charles[1] associated with the high degree of flexion of which the knee-joint is capable in the skeletons of races in which the "squatting" posture is habitual. Thus the frequency and intensity of this feature in the femora of the more primitive races is explained. But observations are not sufficiently numerous to lead to more specific statements than the foregoing.

(*E*) The condition of Platymeria, or flattening of the femoral shaft, now claims attention ; a considerable amount of literature exists on this subject[2]. While the femoral shaft is, generally speaking, cylindrical this statement really needs much qualification, and departures from the cylindrical form are very definite indeed. It must be at once stated that Platymeria implies flattening in

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[1] *Journ. Anat. and Physiol.*, Vol. xxvii. p. 10.

[2] See especially : (1) Turner, *Challenger Report*, xlvii. ; *J. A. and P.* xxi. (2) Hepburn: *J. A. and P.* xxxi. pp. 1 and 116, with full references. (3) Bumüller, *Das Femur des Menschen*, Inaug. Dissert. Munich. (4) Klaatsch, Anat. Heft, Band x. 1900, where extensive references will be found.

two regions of the femoral shaft, viz., in an upper region, immediately below the level of the lesser trochanter, and in a lower region about 40 mm. above the highest level of the external portion of the anterior aspect of the condylar articular surface. These two regions may conveniently be studied apart.

It may be premised that the effect of Platymeria or femoral flattening may be produced by either:

(1)   Transverse widening of the shaft, the sagittal diameter remaining constant.

(2)   Sagittal reduction in thickness, the transverse diameter remaining constant.

(3)   A combination of transverse increase and sagittal decrease in the dimensions of the shaft.

With these considerations in mind, the examination of a series of femora selected from the Therian Mammals will shew that Platymeria is by no means an exclusively human feature of the femoral shaft, and that with regard to its occurrence the following distinctions may be made.

(a)   Theria in which the femur is not platymeric.

Metatheria.	Macropus giganteus.	
		Order.
Eutheria.	Bos.	Ungulata artiodactyla.
	Cervus elaphus.	„
	Hippopotamus.	„

(b)   Theria in which the femur is platymeric.

		Order.
Eutheria.	Erinaceus.	Insectivora.
	Pinnipedia.⎫ Ursidae. ⎬	Carnivora.
	Camelus.	Ungulata Tylopoda.
	Elephas.	„ Proboscidea.
	Rhinocerus.	„ Perissodactyla.

Moreover it is to be noted that such platymeria is the result of transverse widening of the femoral shaft on its external rather

than on its internal margin, which suggests further subdivisions of
Platymeria, for in Man either (1) external widening as a flange-like
process, or (2) internal extension, or (3) both forms of widening may
produce the effect.   (Cf. Fig. 203.)

It is noteworthy that Platymeria
and the presence of a third trochanter
seem to be associated, since both charac-
terize the Perissodactyle in distinction
from the Artiodactyle Ungulata.   In
human femora, too, the most platy-
meric examples usually possess if not
actually a third trochanter, at least a
very well marked gluteal line, such as
bears this trochanter when present; in
human femora which are not platy-
meric, the third trochanter appears
(from my observations) to be rare[1].
In Artiodactylous Ungulates, the enor-
mous size of the great trochanter
seems to exist in compensatory relation
to the deficiency of a third trochanter.
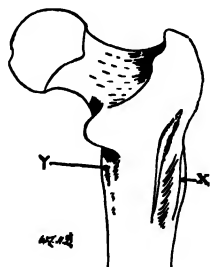
Fig. 203.   Upper end of a
human femur: Platymeria may
be due to (1) extension outward
of a flange-like process (cf. the
flange-like process in humeri
of Gorilla and Megaladapis:) '*x*'
as in Eutheria: (2) extension
inwards as at '*y*' in certain
human femora: (3) '*x*' and '*y*'
may coexist in certain human
femora.

The presence in lowly Eutheria of femoral flattening tends to
disprove its dependence on the erect attitude and the consequent
skeletal and muscular modifications; therefore we shall not be
surprised to find the condition in the Simiidae.   Here, however,
some explanation is necessary.   Compared with the human femur,
that of the Simiidae is flattened or platymeric in a general sense:
the linea aspera is less prominent, and is indeed often indis-
tinguishable; the shaft is consequently very flat, up to and about
its mid-point.   Above this, however, the antero-posterior diameter
tends to increase and the transverse diameter to actually diminish;
further the shaft becomes more cylindrical, largely owing to
a buttress-like ridge which extends downwards from the lesser
trochanter, so that platymeria is often not marked in the same
region as in human femora.   Platymeria exists, therefore, in the
femora of Simiidae, but it is characteristic of the lower parts

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[1] Only superior platymeria is here referred to.

of the shaft, and the particular flattening that is comparable to the superior platymeria of the human femur is frequently lacking. It may occur however, as seen in the accompanying tracings (cf. Figs. 204, 205), in which the flattening seems due to simple lack of development in the sagittal direction, for no such flange-like processes occur as have been described in a preceding paragraph; it would thus appear that transverse increase in growth is not the responsible factor. In the femora of Gorillas a rudiment of the external flange-growth may occur without sufficient prominence to produce the platymeric appearance.
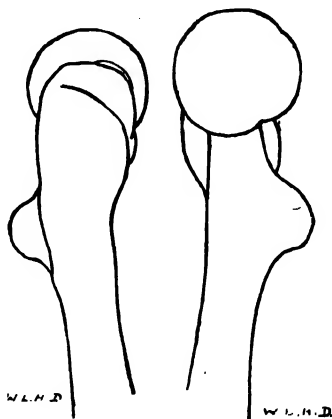
Fig. 204.   Fig. 205.

Fig. 204. Lateral (external) aspect of the upper end of the platymeric femur of an Orang-utan.

Fig. 205. Lateral (internal) aspect of the specimen represented in Fig. 204. (Hose donation II. Mus. Anat. Cant.)

We are now prepared to consider the occurrence of the superior variety of Platymeria in the Hominidae. While age (i.e. maturity) appears a necessary factor in the production of the character, sexual influences seem quite obscure, though Manouvrier's figures shew that the tendency to flattening is slightly less in women than men[1].

An index of Platymeria has been devised, in which the transverse diameter of the shaft is taken as $= 100$, so that the index

$$= \frac{\text{sagittal diameter} \times 100}{\text{transverse diameter}}$$

(the diameters being measured immediately below the lesser trochanter).

The higher the numerical figure representing the index, the

[1] (i) Congrès international d'Anthropologie et d'Archéologie préhistorique, 1889.
(ii) Bull. de la Soc. d'A. de Paris. Séance du 23 Fév. 1893, pp. 130 et seq.
(iii) Bull. de la Soc. d'A. de Paris. Tome VI. Série IV. 1895.

nearer is the approach to equality in the two diameters, and consequently the less the platymeric condition will be manifested. Manouvrier remarks that with the index below 80, the flattening is distinct, and that with a figure less than 65 the character is very pronounced.

The several series investigated shew that the condition is *not* influenced by racial factors: and Manouvrier ascribes its cause to physiological sources, appealing to the effects of over-use of certain muscles. For the present purpose, then, the character loses its interest, but from the point of view of the morphological conformation of the femur it is of such importance that a sketch of the views that are held regarding the action of those physiological causes will be appended.

In expounding a theory of the causation of Platymeria Manouvrier has called attention in the first place to the following point. Platymeria is due to extension of the anterior surface transversely, not only relatively to the sagittal diameter of the shaft, but absolutely, for the extension, which is first marked in man on the inner side, may constitute such a flange-like projection
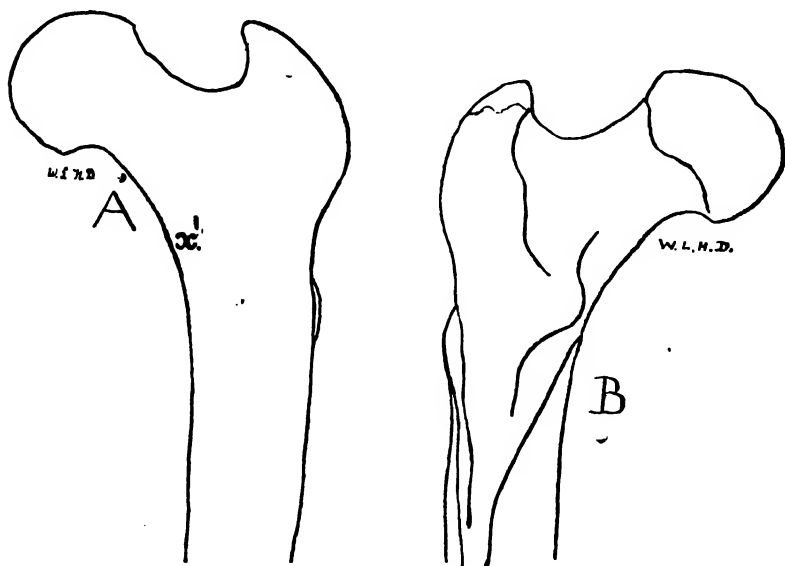
Fig. 206.   Two views, (*A*) the anterior aspect, and (*B*) the posterior aspect of the upper end of a very platymeric human femur: the flange-like projection x' obscures the lesser trochanter when the femur is seen from in front (*A*).

as will obscure the lesser trochanter when the femur is viewed from in front. (Cf. Fig. 206 A, x'.)

In consequence of such flattening, the surface of the femur gains in proportion to the volume of the bone, and thus an extended area is provided for muscular attachments. The muscles chiefly affected are the components of the M. quadriceps extensor cruris (and that these are unevenly affected in different instances is indicated by the occurrence of different kinds of platymeria, which is not always constituted by strictly antero-posterior flattening, but oblique compression). The maximum degree of flattening obtains when to the internal "flange" an external projection is added (cf. also Fig. 206 B, where it constitutes one form of the 3rd trochanter); of this condition a good example is the prehistoric femur from Crècy (with a platymeric index of 56·4), a section of which is represented herewith (Fig. 207). But the special point of Manouvrier's theory is that the action which thus causes these extensions is not the action commonly ascribed to the M. quadriceps extensor cruris, viz. of extending the leg on the thigh, but the inverse action of extending the body on the lower limb: this, Manouvrier submits, occurs at each pace, in its latest phase, and especially in the action of mounting steps or steep slopes.

On these premises, Manouvrier has constructed a theory to the effect that excessive use of the muscles in question has resulted in their hypertrophy, and the consequent extension of their area of attachment, which has been provided for by the projection to which reference has been made.

Fig. 207. Diagram of a section through a very platymeric human femur.

This theory meets the facts that the condition is not influenced by racial factors, and its author claims support on the ground that the same skeletons present (1) platymeria, (2) the fossa hypo-trochanterica (seen immediately beneath the lesser trochanter and bounded by the flange-like extension), and (3) the lateral flattening of the tibia, called platycnemia, all of which are attributable to the same cause ; further, that the associated conditions occur in natives of mountainous regions.

While destructive criticism is notoriously easy, and though no other theory has as yet been advanced with so much plausibility, nevertheless the following difficulties must be urged against the acceptance of that brought forward by Manouvrier.

In the first place, the sexual factor ought to be quite in abeyance, but the figures provided by Manouvrier shew that this influence may quite possibly be effective. Secondly, the condition is not shewn to be universally frequent among mountaineers: admittedly it is so in femora of the extinct Guanche race of the mountainous Canary Islands, but this does not explain the presence of platymeria in ancient (prehistoric) French femora. Thirdly,

platycnemia may exist without platymeria (see under platycnemia). Fourthly, the fossa hypo-trochanterica may also be present without coexistent platymeria: and fifthly, the sporadic distribution of platymeria among other Mammals does not favour such a limited explanation. Sixthly, the comparison of the muscles of the thigh in such examples as Cercopithecus and Man illustrates the behaviour of muscles when compared in two closely allied forms, in which their relative development varies. The upper ends of the femora of Man and of a Cercopithecus monkey are here represented side by side (Fig. 208). The reciprocal develop-
ment of the M. crureus and Vastus internus is seen in the two cases; in Cercopithecus, where the M. vastus internus has assumed consider-able proportions, it is not accommodated with a flange-like extension inwards of the femoral surface, such as the theory postulates for an exuberant M. vastus internus in the human mountaineer; but it encroaches upon the area for the M. crureus, which it apparently sup-plants and displaces. This consideration is of course not absolutely conclusive, for the M. crureus has presumably less tendency to assert itself in the pronograde Cercopithecus than in orthograde Man; never-theless it tends to the detriment of the theory. Seventhly, Macalister points out that certain eminences, such as the so-called tuberculum quadrati, may merely mark the limit of diaphysial and epiphysial ossifications, having no significance with regard to the extent and physiological condition of the (associated) M. quadratus femoris. Notwithstanding these drawbacks, Manouvrier's theory contains the only explanation of the condition as yet proffered, and is accepted by Hepburn[1]. Turner[2] seems to imply that the habitual assumption of a squatting attitude can be appealed to as causal, but the statement is not quite clear.
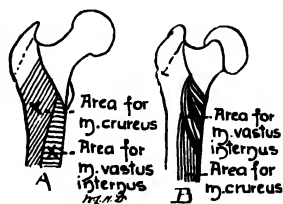
Fig. 208. Diagrams of the areas of muscular attachments to the anterior surface of the femur in (A) Man, (B) a Cercopithecus monkey.

Platymeria has also been observed in the region of the popliteal space of the lower end of the femur: here it is most marked in the femur of the Gorilla (among Simiidae), to which the Orang-utan comes next in order, followed by the Chimpanzee: in the latter, the M. adductor magnus is largely inserted into the popliteal surface, but Hepburn[3] does not clearly state whether this fact can be appealed to in explaining the somewhat raised

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[1] *Journ. Anat. and Physiol.*, xxxi. p. 131.
[2] Variations in the Skeleton, *J. A. and P.*, xxi. p. 473.
[3] Cf. Hepburn, The Trinil Femur, *J. A. and P.*, xxxi. Fig. 1, p. 16.

character of the popliteal surface. This region has attracted an unusual amount of attention in view of its condition in the Trinil femur, the nature of which (as being referable to a member of the Simiidae or Hominidae) has been the cause of so much discussion in common with the associated remains (cf. Chapter XVII.). In the Trinil femur the popliteal area bulges, lacking the flatness so constant in normal human femora[1]: Hepburn's researches shew that although the flattening is so constant, nevertheless exceptions within the Hominidae do occur, constituting parallels to the Trinil femur which ought not therefore to be regarded as absolutely excluded from that family. And while Hepburn's researches revealed but few such exceptions, yet it is noteworthy that a skeleton of an aboriginal of Australia provided the example in which the condition of the Trinil femur was almost exactly reproduced. It is only right to add, in illustration of the extreme variability of the character, that this is a left femur, and that the right femur of the same skeleton falls far short of its fellow in this respect. In fact no racial variation was found, nor is the condition dependent on sex or age, for which reasons it will not here be further discussed. A variety of measurements of the lower end of the femur were made by Bumüller in Ranke's laboratory at Munich, but have no bearing on the special subject of the present chapter.

The Tibia. The principal variations in the form of the tibia relate to

(A)   The external portion of the upper articular surface.

(B)   The backward curvature of the upper portion of the shaft (and retroversion of the head of the tibia).

(C)   The proportions of the sagittal and transverse diameters of the shaft at the level of the nutrient foramen, and platycnemia.

(A)   The external portion of the upper tibial articular surface, or external condylar surface, upon which the external semilunar cartilage rests, varies in convexity in the Simiidae and Hominidae: a high degree of convexity is said by Thomson[2] to characterize the

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[1] Pathological, *e.g.* rickety, femora may present such bulging in the popliteal space.

[2] *J. A. and P.*, Vols. XXIII. 616, p. xxv., and XXIV. 210, " Influence of posture on the form of the tibia."

former, and also the lower Hominidae: but the character is really, in all probability, a physiological one, and associated with an habitual "squatting" attitude: in such races, whatever their other morphological characters may be, as do not habitually rest in a squatting position, the convexity of the surface in question is less pronounced.

The occurrence of a high degree of convexity is thus more frequent in the black races than in the white, as the former group contains more examples in which the squatting attitude is the habitual resting posture. This posture is associated with an extreme degree of genuflexion[1]. With the same excess of flexion at the knee, would seem to be associated, the retroverted appearance observed in certain tibiae, more frequently it is alleged in the skeletons of squatting races, and with these characters is associated again the existence of articular facets on the anterior margin of the inferior articular tibial surface[2].

(B) A retroverted tibial head would, according to Thomson, probably coincide with a less pronounced articular convexity of the surface just described, compensation being provided by the retroversion. It is a noteworthy point that at one period such retroversion of the head of the tibia on its shaft was thought to imply that the individual presenting this appearance had not yet attained the erect attitude fully: Manouvrier seems however to have shewn that this inference is incorrect, and that the erect attitude may be perfectly attained by an individual presenting simultaneously marked retroversion of the head of the tibia. The latter character is however associated with the extreme of genuflexion as just mentioned, and further, though less probably, with what Manouvrier has described as "la marche en flexion" or walking with the knee at no time fully extended. This particular gait (which Manouvrier considers more frequent among mountaineers) would accordingly be associated with platymeria, extreme power and extent of flexion of the knee-joint, and platycnemia, or tibial flattening from side to side.

To the accessory facets at the lower end of the tibia correspond

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[1] Thomson remarks its greater frequency in tibiae of fossil Man (*op. cit.*).

[2] Cf. Havelock Charles, *J. A. and P.* XXVIII. p. 14; Arthur Thomson, *op. cit. ibid*: and Baetz, *Verhand. der Berliner Ges. für Anthr.* 1901, s. 203.

similar facets on the outer side of the astragalar neck, which in extreme flexion of knee and ankle come into contact with the former, and are therefore regarded as witnesses to the squatting habit, and as developed in relation therewith.   Thomson clearly distinguishes these external astragalar facets from others described in cases of Talipes varus as occurring on the internal side of the neck of the astragalus, not on its external surface.

The foregoing conditions constitute in some degree differences between tibiae of the Simiidae and Hominidae.   The former, as has been remarked, present external condylar surfaces with pronounced convexity, but do not appear to be characterized by retroversion of the head of the tibia upon the shaft.   With regard to accessory inferior tibial and astragalar facets, the conditions in the Simiidae vary, for the facets are said to be common in Simia and Gorilla, but rare in Anthropopithecus.   When present, they may be associated with the freedom and extent of ankle flexion in climbing movements[1].   Among the Hominidae, Collignon[2] and Fraipont[3] have recorded the existence of retroversion of the head of the tibia in the fossil human skeletons, particularly (Fraipont) in the famous Spy skeletons.   Charles[4] has recorded the astragalar articular facets referred to, in the skeletons of natives of India; and foetal and infantile astragali of Punjabi natives in the Cambridge Museum shew similar facets.

(C) Platycnemia or flattening of the tibial shaft is a very striking anomaly, and has consequently attracted much interest. The results of numerous investigations (chiefly conducted by Manouvrier), tend to shew that the condition is to be regarded as a physiological character developed in relation to environment and habit.   The flattening, it will be remarked, is in a plane at right angles to that of the commonest variety of platymeria, and in human skeletons the area of tibial attachment of the M. tibialis posticus is drawn backwards in the form of a keel or flange, which thus increases the sagittal diameter of the tibial shaft, the transverse diameter experiencing comparatively little change.   It is

[1] Cf. Thomson as quoted by Charles, *J. A. and P.* xxviii. p. 15.
[2] Collignon, *Revue d'Anthropologie*, 1880.
[3] Fraipont, *Revue d'Anthropologie*, 1887.
[4] Charles, *J. A. and P.* xxviii. *loc. cit.* p. 15.

undeniable that the affected part of the shaft lies posteriorly to the interosseous membrane, and that in this respect the flattening, or, as we may now describe it, the extension of the shaft differs in the Hominidae, in which it is backward in direction, from the apparently similar flattening, or extension of the shaft observed in many instances among the Simiidae, in which however the surface affected may be partly anterior to the line of the interosseous attachments.

Manouvrier[1] has made the following observations on the condition of platycnemia.

(1)   As regards the influence of age, the appearance of platycnemia is associated with the attainment of maturity: absent in childhood, it appears in later adolescence.

(2)   As regards the influence of sex, it appears most marked in male tibiae: and also associated with this observation is that which records the greater frequency of platycnemia in short, than in tall individuals.

(3)   As regards the racial distribution of platycnemia, the remark made by Manouvrier, to the effect that platycnemic and non-platycnemic tibiae may occur in any population, would seem to preclude us from the necessity of further considering the character in the present connection.   We will content ourselves therefore by appending a brief note setting forth some of the associated conditions.

Platycnemia is undoubtedly common in certain prehistoric races of Western Europe and Egypt.   In modern times it occurs in a pronounced degree in rickety tibiae, and in the tibiae of certain ill-fed and badly nourished Australian aboriginal tribes (cf. the description of the "boomerang"-tibia by Messrs Spencer and Gillen, *The Natives of Central Australia*).   Pruner-Bey attributed all platycnemic cases to Rachitis (Rickets).   Broca controverted this view, and suggested that the condition is due to enfeebled action of the muscles of the calf of the leg (the sural musculature).   Finally Manouvrier proposed his theory, which exactly traverses Broca's view, that over-action and not enfeeblement, is the physiological cause, and that the muscle chiefly

[1] *Bull. de la Soc. d'A. de Paris*, 4° Série, Tome x. p. 128, 1887.

in question is the M. tibialis posticus. It is submitted that examination of the associated conditions in the tibia reveals no modification of the soleal line, either by way of increase or decrease, so that the inference is that probably the calf muscles were not enfeebled, as suggested by Broca. Again the area of attachment of the M. tibialis anticus has undergone no change, so that apparently no encroachment has occurred from this side. Lastly however the area of attachment of the M. tibialis posticus is found to be profoundly modified, and this observation led to a theory of the production of platycnemia, based upon the views held as to the action of the M. tibialis posticus. The argument is set forth somewhat in the following way. The action of the M. tibialis posticus is not always that of flexion with adduction of the ankle-joint, for when the foot is fixed, the action of the muscle will be reversed: taking its origin from below, the muscle will tend to fix the tibia, and support it, especially where there is slight extension of the ankle as in running and jumping. Excess of this action would thus lead to hypertrophy of the M. tibialis posticus, and this would be met by a corresponding development of the osseous tibial attachment of the muscle, and the consequent production of the posterial tibial crest or ridge, upon which the occurrence of platycnemia depends.

The condition might hence be expected in any group or tribe inhabiting a district which involved the exercise of much exertion in locomotion. A mountainous district supplies such a necessity, and the attempt has been made to shew that platycnemia is especially frequent in races inhabiting mountainous districts. This view is shewn by Charles[1] to be inapplicable to the Punjabi natives, nor can the great frequency of platycnemia in the prehistoric tibiae from Egypt (in the Cambridge Museum) be accounted for by the theory. There may be varieties dependent on mal-nutrition; the sexual difference would be explained by the greater muscular development and activity of the male: and the platycnemia of the Simiidae is shewn to depend, not solely upon modification of the area of attachment of the M. tibialis posticus, but also to some extent on correlated modification in the area

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[1] *J. A. and P.* **xxviii.**

of attachment of the M. tibialis anticus, whereby it is differentiated for human platycnemia. A satisfactory explanation of platycnemia in the Simiidae may be found in an appeal to their arboreal mode of existence.

The frequency of platycnemia, as well as of platymeria and the conditions indicative that the squatting posture was habitual in the prehistoric and fossil human races, is a remarkable fact, of which no fully satisfactory explanation is as yet forthcoming.

An index of platycnemia is obtained as follows. Measurements of the shaft are made at the level of the nutrient foramen, and the antero-posterior and transverse diameters are compared, the antero-posterior diameter being taken as = 100, and the index

$$= \frac{\text{transverse diameter} \times 100}{\text{antero-posterior diameter}}.$$

The following values are quoted by Manouvrier:

average indices: (10) modern French (men)　　　88·2

,,　　,,　　　　　　　French (women)　80·6 to 108·3

,,　　,,　　(18) Negroes　　　　　85·3 ·

,,　　,,　　(21) Pre-Columbian Venezuelans 76·1,

while the following values for Mori-ori natives are from my measurements upon specimens at Cambridge:

Skeleton A: right tibia, index 77·7.

Skeleton B:　,,　　,,　　,,　66·6. ·

Skeleton B: left　,,　　,,　60,

the degree of flattening and platycnemia being very pronounced in the latter example.

The Astragalus. In considering the astragalus, reference must again be made to the supernumerary facets met with in this bone in such races as "squat" (as well as in the foetus of such races). Mention must now be made of a character which, though not established as a differential racial feature, may yet be shewn to possess such a value. This is the angle at which the neck of the astragalus is set upon the body of the bone. The angle is included by, (a) the line passing along the external border of the neck, and (b) the line of the internal articular (malleolar) surface. This character distinguishes the Hominidae clearly from the

Simiidae, for in the latter the numerical value of the angle varies from about 30° to 40°. Within the Hominidae the factor of age is very important, for Shattock (quoted by Bland Sutton in Morris' *Anatomy*) has shewn its average value to be about 35° in the foetus towards the end of pregnancy. In adults of white races, the value has diminished to about 10°. With regard to sexual differences, information is not forthcoming, and in respect of racial variations is but scanty. With the figure (10°) just given for the white races, there may however be contrasted the value recorded by Sewell[1] as the average in prehistoric Egyptian astragali (Naqada race), viz. 18°. (Cf. Fig. 209.)
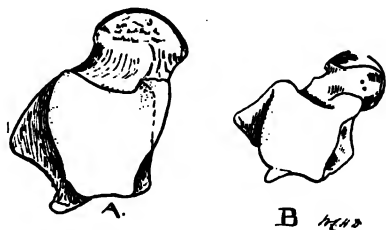
Fig. 209. Astragali (of the left side) of (*A*) Man, (*B*) Chimpanzee, shewing the greater obliquity of the neck in the latter form.

Calcaneum. The projection of the os calcaneum behind the ankle has been described as characteristically great in the African negro races. If the appearance be not altogether due to the feeble sural musculature in those races[2], it should not be looked upon as necessarily a feature denoting inferiority; for in the comparison of the Simiidae with the Hominidae, a gradual increase in the backward projection is to be noted, from Hylobates and Simia in which it is minimal, through Anthropopithecus niger, in which the heel begins to assert its future prominence, and so through Gorilla, in which the human heel is clearly enough foreshadowed, to Homo; a high degree of posterior projection must therefore be regarded as an intensification of a character which reaches its highest point in Man among the Primates. Otherwise, the condition is not uncommon among Eutheria, and

[1] *Journ. Anat. and Phys.* Vol. xxxviii., *v. supra*, Chap. vii. p. 176, footnote. An exhaustive research on the form of the astragalus has been recently published by Volkov, *Bull. de la Soc. d'Anth. de Paris*, 1903.

[2] Topinard could make out no difference in the skeletons of white and black races in this respect, but reserves judgement, stating that American observers have demonstrated the excessive backward projection in living negroes (cf. *Él. d' Anth. gén.* p. 1048). Laidlaw, *Brit. Ass. Adv. Sc.* 1904, stated that the heel-bone in Egyptians is about 3 % longer than in white men.

particularly among such as excel in speed, for the long calcanean lever thus formed enables the sural group of muscles to act to greater advantage, and this, it may be incidentally remarked, may explain the feebler development of those muscles in such instances as are accompanied by marked calcanean projection: in these, the amount of muscle substance required would necessarily be less than where less leverage is afforded by the conformation of the skeleton.

From the consideration of descriptive characters, we pass to that of the proportions of the several skeletal segments, as compared by means of measurements. The fundamental base or canon of all such comparisons would seem naturally to be the stature, but the measurement of this dimension in skeletons is fraught with so much likelihood of serious error in observation, that in the present account it will not be adopted. With whatever canon that may be employed, it would be reasonable to compare the length of such naturally demarcated portions of the body as the limbs, the trunk, the head and neck. It will thus be evident that a great number of comparisons might be instituted, but only a selection of very modest dimensions will be submitted for consideration in the present place, and we propose to limit the list of comparisons to four, viz.:

(a) The length of the upper as compared with that of the lower limb, exclusive in each case of the terminal portion (hand and foot); i.e. the relation, $\dfrac{\text{radial and humeral lengths combined}}{\text{tibial and femoral lengths combined}}$.

(b) The comparative lengths of proximal and distal segments of the upper limb (without the hand); i.e. the relation, $\dfrac{\text{radius}}{\text{humerus}}$.

(c) The comparative lengths of proximal and distal segments of the lower limb (without the foot); i.e. the relation, $\dfrac{\text{tibia}}{\text{femur}}$.

(d) The comparative length of the proximal segments of the lower limb (femur), and of the upper limb (humerus); i.e. the relation, $\dfrac{\text{humerus}}{\text{femur}}$.

It will be noticed that the selection of the exact objects for comparison has been somewhat arbitrary, but it can at least be

urged that this selection is justified, both by the satisfaction of morphological requirements and by the interest of the results obtained.

The conventional measurements of the humerus and radius are the maximum lengths of those bones placed in any position whatsoever: but the bones of the lower limb require a certain adjustment before the measurements can be made in accordance with the method adopted by earlier observers. Thus the femur is measured in what is known as the oblique position, i.e. the length is measured between plane surfaces, one touching both the condyles, and the second parallel to the first, and touching the head of the bone. The bone is best measured upon a board with uprights; the board used in the Cambridge laboratory has the appearance shewn in Fig. 210.
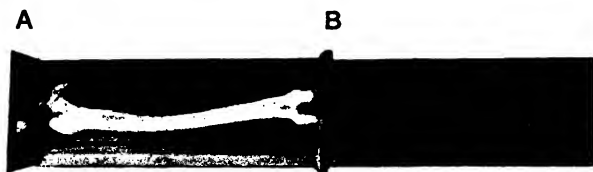
Fig. 210. Osteometric board used in the Cambridge Anatomy School.

The scale is fixed along the margin of the board: the uprights A and B are set perpendicularly to the board and square to the scale: and B slides along the board to and from A.

The maximum length of the tibia is not recorded; but the length is measured between the upper articular surface and the tip of the internal malleolus: the tibial spine on the upper surface is thus excluded, and a cavity in one of the uprights admits of this allowance being made.

For the sake of brevity, we may now indicate the lengths of the several bones by initial letters, so that "R" is the length of the radius, "H" that of the humerus, "F" and "T" those of the corresponding bones of the lower limb. "$H + R$" thus denotes the length of the upper limb (minus the hand), "$F + T$" that of the lower limb (minus the foot).

The intermembral index. Our first investigation is directed to the relation of $H + R$ to $F + T$ as has already been indicated.

In an earlier chapter we have seen that the Hominidae are distinguished by the great development in bulk and length of the lower limb, as compared with the Simiidae, and that whereas in the latter the combined lengths of humerus and radius exceed the combined lengths of femur and tibia, the exactly converse relation characterizes the Hominidae. But also it is known that the Simiidae are not all characterized in the same degree by this relation and that the excess of fore-limb length over hind-limb length is less in some species than others. We have now to enquire whether the Hominidae are uniform as regards the converse relation, and whether there may not be discoverable some such variation as has just been noted in the Simiidae. To make the results more easily comparable the method of expression by means of an index has been adopted and this is termed the "Intermembral" Index. Considering the length of the lower limb as $= 100$, the index

$$= \frac{\text{length of upper limb} \times 100}{\text{length of lower limb}}.$$

(Cf. Fig. 211.)

Fig. 211. Diagrams to represent the skeleton of the limbs as compared in the intermembral index: if the lower limb be considered as of constant length, the upper limb may be relatively either short as in (A), or long, as in (B).

We may first compare the Simiidae with the Hominidae as regards this index: in the former family the index provides values which range from 141 in Simia (Humphry. *The Human Skeleton*) to 104·6 in Anthropopithecus niger[1]: in other words, the com-

[1] Other figures from observations on specimens at Cambridge may be here appended, together with the results recorded by Humphry, and Turner (*Chall. Rep.* XLVII.).

Hylobates:	av. of 2	132·5	(W.L.H.D.
Orang-utan:	,, 2	141	(Turner and Humphry.)
,,	,, 1	137·5	(W.L.H.D.)
Gorilla:	,, 3	119·4	(W.L.H.D.)
,,	,, 3	117	(Humphry).
Anthropopithecus Niger	,, 3	104·6	(Turner.)
	,, 1	105·5	(W.L.H.D.)
	,, 1	103·5	(Humphry.)

The Chimpanzee is thus the most human, the Orang-utan the least human in this respect.

bined lengths of humerus with radius exceed those of femur and
tibia by amounts varying from 4·1 to 4·6 %. In Man, as we have seen,
the combined lengths of femur and tibia are in excess, and
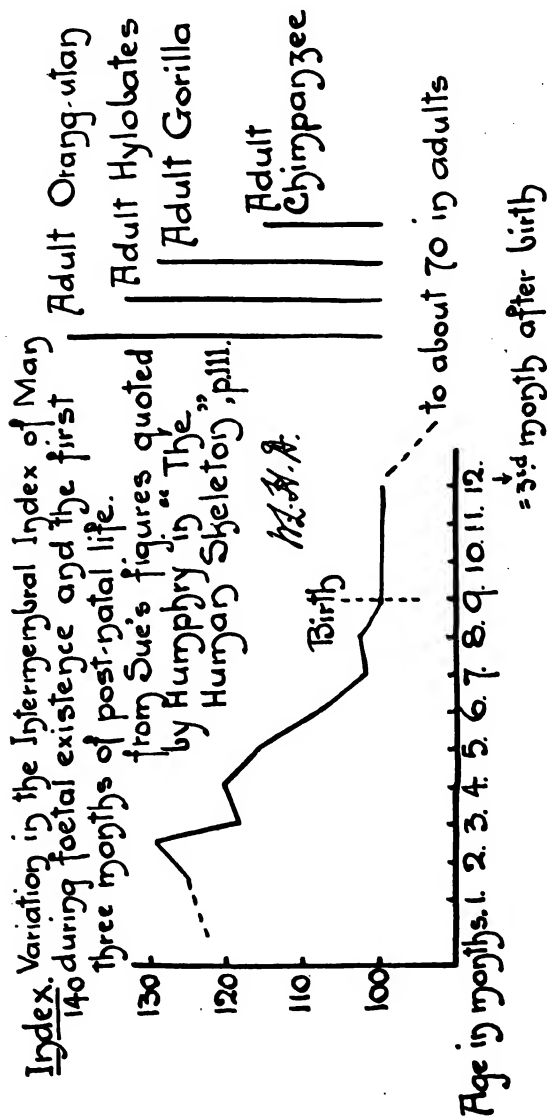
Chart A.

the index accordingly falls short of 100, and actually the range observed is from about 66 to 67.

Within the Hominidæ we must now consider the influences of age, sex, and race, as in so many other instances.

Age is undoubtedly a most potent factor up to the time of the appearance of the permanent teeth (7—8 yrs.). In a foetus of four months and a half the very simian character of the proportions of upper to lower limb-length is brought out by the intermembral index: the value of this is 98·6, which is not so very remote from the figure provided by the adult Chimpanzee (103·5—105·5); but it is an individual measurement, and the value of the index given by Sue's figures (see chart A) is from 116 to 120, which surpasses the index in the Chimpanzee.

The variations in the index from month to month in foetal life may be conveniently displayed as a chart, and are represented in the accompanying figures (A and B)[1].

The gradual assumption of the human proportions is here clearly shewn, and the second chart (B) carries the observations on into post-natal life. The slight irregularity towards the end of adolescence is due to the number of observations being insufficient for uniformity to be complete. But the simian stage was passed by the seventh month of foetal life.

The influence of sex must now be sought, and in adult Europeans is seen to be practically nil, for, accepting Topinard's figures[2], the average index for male and female alike is 69·5. As regards race, the observations collected by Turner[3] prove most useful in demonstrating the differences which obtain. The following values are quoted by Turner as averages computed from the records of other observers as well as from his own work.

Aborigines of Australia			68·7
African Negroes		...	68—69
Andamanese	...	...	68·9
Europeans	...	...	69·7
Bush race	...	...	67·3

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[1] These charts are based upon data recorded or quoted by Humphry (*The Human Skeleton*, pp. 110—111).

[2] *Él. d' Anthr. gén.* pp. 1040, 1041.

[3] *Chall. Rep.* XLVII.

Eskimo...	...	73·4
Lapps ...	...	72·8
Bambute Pygmies		83·6 (Shrubsall)[1].

Variation in the Intermembral Index
of Man, during the first twenty
years of life ; compiled from
figures provided by Humphry
in "The Human Skeleton", p.111.

W. L. H. D.
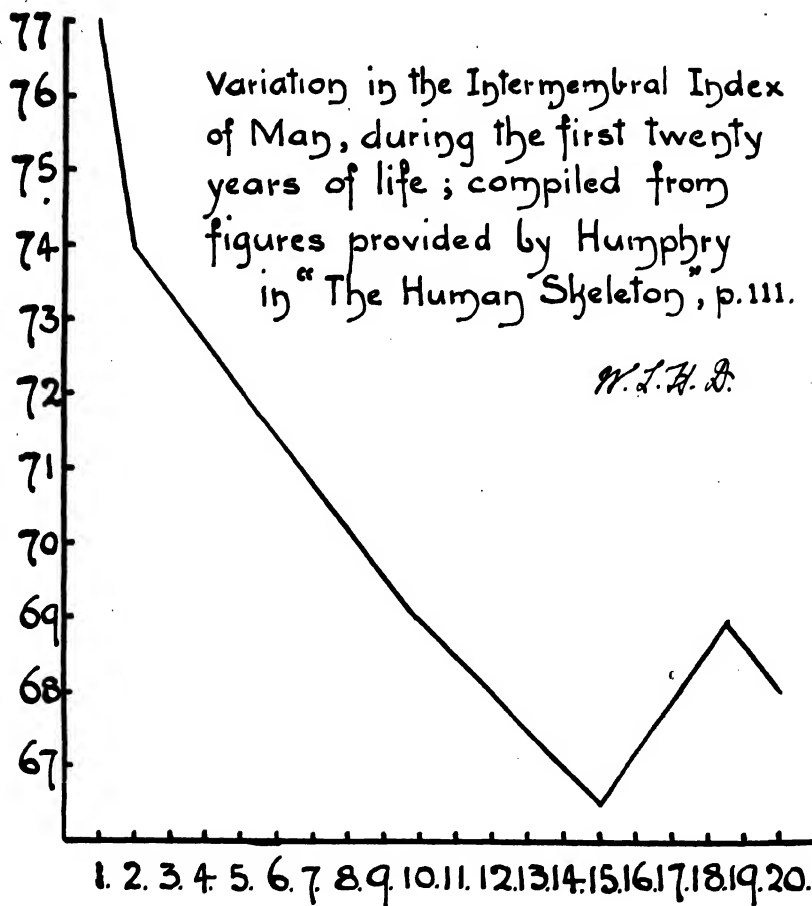
Chart B.

Whence it appears that, while the Eskimo, Lapp and African
Pygmy races are most nearly allied to the Simiidae, yet the (adult)
Hominidae are as a group far removed from these: moreover the
white races occupy an intermediate position, and the black races

[1] Cf. Johnston, *The Uganda Protectorate.*

of full stature have even shorter arms than these (in propotion to their length of leg). It may at once be noticed that the Eskimo index is the average of two individuals only, and may need revision; and in fact the Eskimo skeleton at Cambridge has an intermembral index of about 69 (69·6 actually). The great length of upper extremity in the Eskimo is due to great humeral, not to radial length. As regards the black races, the great length of lower limb in certain of these, especially the Soudanese, is a matter of common knowledge, but at the same time it is a character which places them in a category morphologically superior to that to which the white races are to be relegated.

The radio-humeral index. The second relation to be considered is that of the radius to the humerus, and this is commonly expressed in the form of the ante-brachial or radio-humeral index, derived from the formula (H = 100)

$$\text{Index} = \frac{R \times 100}{H} \quad \text{(Cf. Fig. 212.)}$$

The numerical value of this index in the Simiidae ranges between 80·1 (in a Gorilla at Cambridge), through 94·5 in a Chimpanzee (Mus. Anat. Cant.) (Turner and Humphry[1] give 94 as the average for Chimpanzees), and 102·7 in Simia (Mus. Anat. Cant.), to 115·5 in a Hylobates (Mus. Anat. Cant.). In the Hominidae, the index rarely exceeds 81 (though 85·7 is on record), nevertheless the two families overlap in respect of this index.

The modifications of this index in relation to age and development within the Hominidae, have been well demonstrated by Hamy (quoted by Turner, *op. cit.*)[2], and the results obtained by that author shew that the human foetus is in this respect distinctly simian up to the mid-stage of pregnancy, after which the human proportions are somewhat rapidly acquired. The index in the foetus at $2\frac{1}{2}$ months is said to be 88·8, and at the time of parturition the
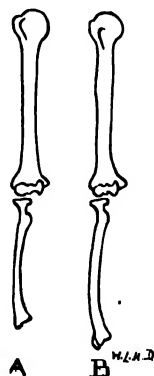
Fig. 212. Diagram of the bones as compared in the radio-humeral index: the length of the humerus being taken as the constant factor, the radius may be relatively either short (*A*) or long (*B*).

Op. cit. v. p. 331, *supra.*   [2] Cf. p. 331, *supra.*

value has sunk to 76·2 (in white races).   The accompanying
chart (C) gives an indication of the changes.

Variation in the
Radio-humeral
Index of Man
from the foetal
period onwards,
compiled from
Hamy's figures.
W.L.H.D.

Birth

Index. 89 88 87 86 85 84 83 82 81 80 79 78 77 76 75 74 73 72 71 70

Age in years. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10

Chart C.
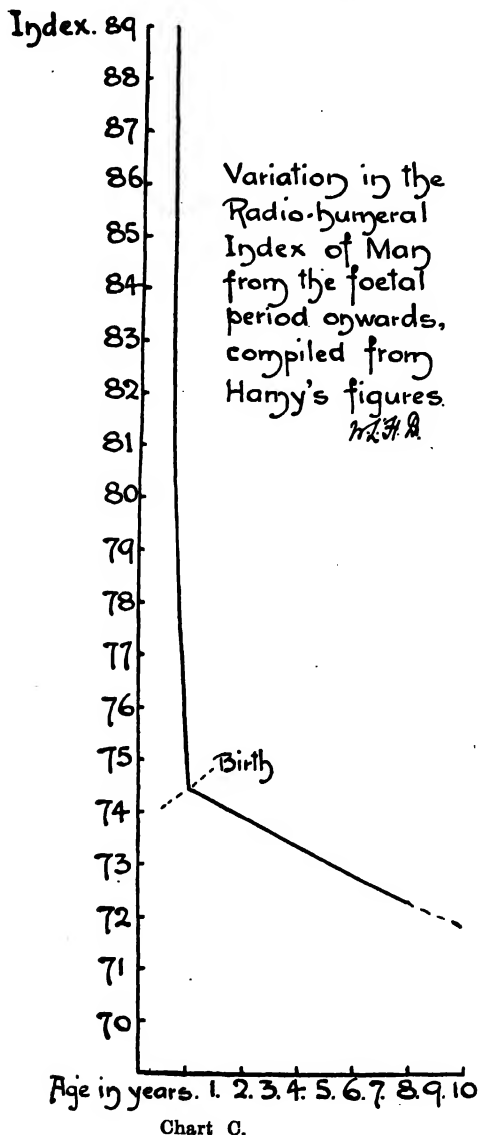
The sexual difference in the proportion of radius to humerus is very slight, but there is an indication that the radius is relatively shorter in Woman: the difference in white races does not amount to more than about ·4 in the average value of the index (72·5 ♂ : 72·1 ♀).

When we turn to the several human races, we find that, as regards the figures representative of the index, examples such as 77·6 occur for an aboriginal of Australia, 68·6 for a Bushwoman (both in the Cambridge Collection) while Turner (*op. cit.* p. 331, *supra*) has drawn up a three-fold classification of the human races, based on the index, the dividing lines being at 75 and 80.   Limbs in which the index is less than 75 have relatively short radii, and are furthest removed from the simian type: when the index is between 75 and 80 the proportions are indifferent, but above 80 the radius is so long as to resemble that of the Gorilla, and in a lesser degree those of the other Simiidae.   Turner's classification may be given as follows :

Brachy-kerkic group.   The radio-humeral index is less than 75.

Europeans	(IV)[1]
Lapps ...	(IV)
Eskimo ...	(VI)
Bush race	(VII).

Mesati-kerkic group.   The radio-humeral index is between 75 and 80.

Aboriginal Australians ...	(I)
Veddahs	
Polynesians	(V)
African and Oceanic Negroes	(II and I)
African Pygmies	
? Yellow races	(IV).

Dolicho-kerkic group.   The radio-humeral index is greater than 80.

Andamanese ...	(III)
Some African Negroes	(II)
Fuegians	(IV)

and *Simiidae* in general.

[1] The numerals refer to the groups described in Chapter XVI.

The tibio-femoral index. The relation of tibial to femoral length is expressed by the tibio-femoral index, which is derived from the formula ($F = 100$)

$$\text{Index} = \frac{T \times 100}{F}. \quad \text{(Cf. Fig. 213.)}$$

The comparison of the Simiidae with the Hominidae leads to the following conclusions as to this index: the Hylobates and Orang-utan are characterized by a relatively (to the femur) long tibia, and though the Gorilla and Chimpanzee are not usually so characterized, examples (such as No. 3 W.L.H.D. priv. coll.) occasionally present the proportion in question. The figures collected by Turner shew that the Gorilla and Chimpanzee have a comparatively short tibia, with an index below 83, this figure being occasionally exceeded by the Orang-utan. This is the case with at least one Orang-utan limb (index 86·2) in the Cambridge Anatomical Museum, also with one limb of Gorilla (index 86·1, as mentioned above), one limb of a Chimpanzee (index 86·3), and more definitely so with respect to two skeletons of Hylobates (Hose Donation II., Mus. Anat. Cant.), the figures being 89·9 and 90·3 respectively.

Fig. 213. Diagram of the bones as compared in the tibio-femoral index: the length of the femur being taken as the constant factor, the length of the tibia may be relatively either short (*A*), or long (*B*).

The higher the numerical value of the tibio-femoral index, the more definitely simian are the proportions of the two bones in question.

The influence of age in the Hominidae is illustrated by the figures recorded by Humphry (*The Human Skeleton*, p. 111), and an instance given of the index in a foetus of $4\frac{1}{2}$ months (W.L.H.D)[1]; the result is to shew that the human proportions are variable and approximate on the average to the figure 80 as a mean in the period from midway through intra-uterine life, to the attainment of maturity. But no distinctly simian character in the foetus is

[1] Cf. *Studies from the Anthropological Laboratory*, p. 18.

revealed by this series of figures, which has been plotted out in the form of a curve in the accompanying chart D.

Variation in the Tibio-femoral Index in Man from the middle (4½ months) of foetal life onwards; from figures recorded by Humphry, "The Human Skeleton". p. 111.
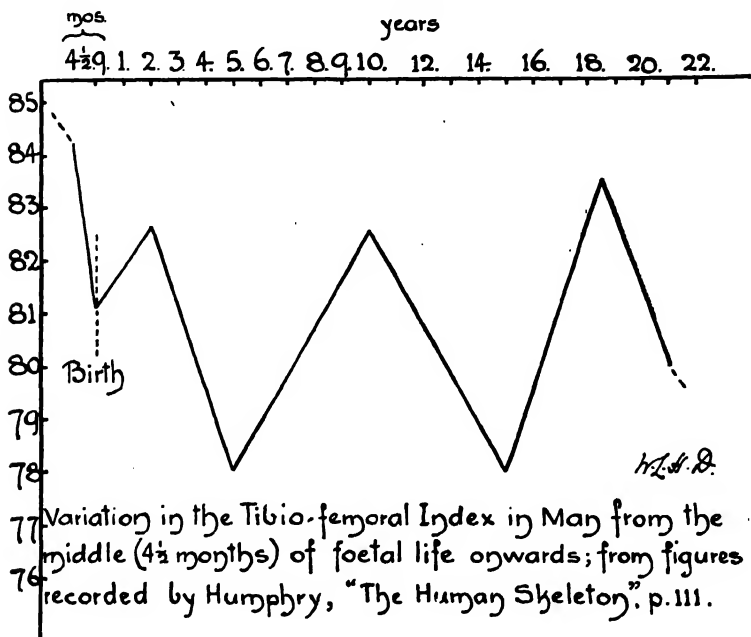
Chart D.

A slight sexual variation is noticed, comparable to that which is indicated by the radio-humeral index; for the average value of the tibio-femoral index in white women is less (80·8), i.e. they have shorter tibiae relatively to the femoral length (for the work of Manouvrier shews that they have shorter femora than men), than white men (av. 81·8) who are more simian than women in this respect.

For the effects of racial variation, recourse must be had again to the data collected by Turner[1] who distinguishes races with a relatively short tibia as brachycnemic, from a dolichocnemic group: the division is made arbitrarily at the figure 83, and the following classification results:

A.   Index below 83.   Brachycnemic class: Europeans, most yellow races, Eskimo.

B.   Index over 83.   Dolichocnemic class: Aborigines of Australia, Negroes, Andamanese, African Pygmies[1], and probably, though not certainly, Bush natives.

The **humero-femoral index** (often alluded to as the femoro-humeral index).   The femoro-humeral index affords a means of comparing the relative lengths of humerus and femur, and the femoral length being taken as = 100, the index is $= \dfrac{H \times 100}{F}$ (cf. Fig. 214).   In respect of this proportion, the Simiidae (with the exception of the Chimpanzee) contrast strongly with the Hominidae, for in the former the humerus is actually longer than the femur.   Specimens in the Cambridge Museum yield the following data: in Hylobates (av. of two) the index is 117·5 (the humerus is thus 17·5 % longer than the femur); in one Simia the index is 126.   The average value of the index in three Gorillas is 121·5.   (W. L. H. D. priv. coll.)   These figures are in accordance with the records quoted by Turner, Flower, and Humphry[2].   A Chimpanzee skeleton gives an index of 101.   Flower quotes 100 (equality in length) as the figure, but Turner and Humphry obtained figures of the values of 97 and 98 respectively, shewing that in the Chimpanzee is seen the nearest approach to the condition typical of the Hominidae; in the latter the index is well below 100.

Fig. 214.   Diagrams of the bones as compared in the femoro-humeral (or humero-femoral) index: the length of the femur being taken as the constant factor, the length of the humerus may be relatively either short (*A*), or long (*B*).

Within the Hominidae, the change in the proportion of humeral to femoral length is represented diagrammatically in the chart (E) drawn up from data provided by Humphry[3]; the value of the index is seen to be 81·5 at birth: but at an earlier stage, viz. half-way through the period of pregnancy, the foetus yields an index

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[1] Shrubsall, in Johnston's *The Uganda Protectorate*.
[2] In Turner's Report on the bones of the human skeleton, *Chall. Rep.* XLVII.
[3] *The Human Skeleton*, p. 111.

Variation in the
Femoro-humeral
Index in Man,
from birth onward.
Compiled from
figures given by
Humphry, " The
Human Skeleton"
page 111.

K.L.H.D.
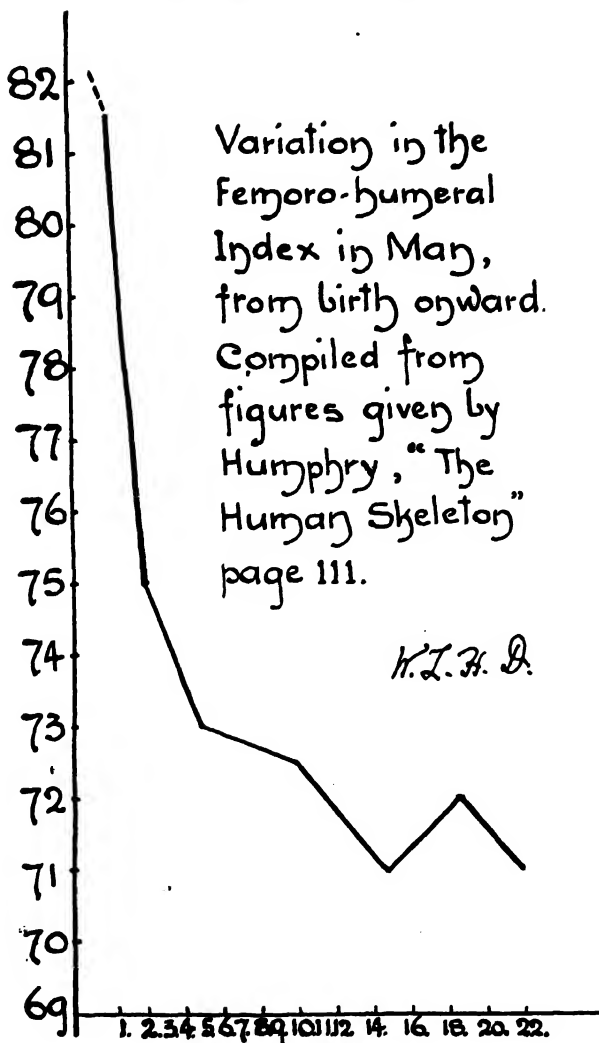
Chart E.

The abscissae represent the age in years. It is remarkable that in all the charts, with the exception of that relating to the Tibio-femoral index, the curve is of the same character, viz. a curve descending from left to right. Moreover, the higher points on the curve are those which approximate the Hominidae to the Simiidae in the several characters investigated. It thus appears that in respect of each of these, the condition is more simian in foetal and infantile life, the characteristic human conformation being acquired with maturity.

of 100, i.e. the humerus and femur are of equal length (foetus in the Cambridge Anatomical Museum). The foetal condition is thus distinctly simian, but by the time of birth the final human characteristic proportion has been nearly attained.

From the data collected by Topinard[1], it would appear that a sexual difference exists, the male humerus being longer (for it is improbable that the other condition to which the result might be ascribed, viz. that the female femur were the longer, should be the cause[2]), but the figures give rather conflicting results.

With regard to racial variations, numerous data have been collected by Turner and others, from which it appears as though the Central African Pygmies are the most simian of all Hominidae in this respect (index 80·3).

Among the taller Hominidae, the Eskimo race present the longest humeri and therefore the most simian character[3], whereas the white races are intermediate, and the black races least simian in this respect.

With the humero-femoral index we conclude the account of the proportions of the limbs and their chief segments as measured in the skeleton. A general survey shews that the final condition in Man is usually reached in the post-natal stages of growth and that with regard to racial variations, there is no uniformity in respect of the indication provided by the several characters. The simian features are thus distributed irregularly among the human races.

A factor that has not been directly discussed, but which is a very important one, is that of absolute bulk as measured by stature. For instance in comparing individuals of tall stature with those who are short, no matter of what race, the tall person owes his superior height rather to excess in length of the lower limb than to excess of trunk-length. A tall person then (of any race) tends to possess intermembral proportions indicative of short upper and long lower limbs, and thus is far removed from the type of the Simiidae, in which the upper limbs are long, and the lower

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[1] *Él. d'A. générale*, pp. 1040, 1041.   [2] Cf. p. 337 *supra*.

[3] It must be added that the skeleton of the Eskimo woman in the Cambridge collection, does not bear out the above statement, the index is here 72·4, whereas the average given by Turner is 77·7.

are short. (Herein we may find the explanation of the position of the tall negro races.) Again, when we dissect (so to speak), the limb of the tall man, to find out whether both femur and tibia have shared equally in the total increase to which the tall man owes his stature, we find that the femur has increased to a greater extent than the tibia. From this it follows that independently of race, tall individuals will tend to have longer femora than short persons, and the effect of this will be felt in the tibio-femoral and humero-femoral indices, so that simply by reason of their stature, the tall are less simian in proportions than the short, and so the apparently paradoxical position of the black races as regards these features and the corresponding indices may be explained.

Again, precisely similar considerations affect the influence of sex, for the male being usually taller than the female, similar differences (though unlike in degree) will be discovered, and in this way sexual differences may be elucidated.

The differences obtaining in the two limbs, i.e. between the right and left limbs must also be taken into consideration, but the influence of this factor on the averages will be reduced by increasing the number of observations.

The foregoing remarks on the proportions of the limbs are suggested by exhaustive work on the subject by Manouvrier[1] as regards the differences due to right or left limbs being measured, and a *résumé* of researches is given by Turner[2] in the monograph so often referred to.

Limb-bones in relation to stature. This subject suggests the consideration of the relation of the length of the limb-bones to the stature, and the problem of the reconstruction of the stature from the length of one or more long bones of the skeleton. It must be premised that such reconstruction can only amount to an approximation, owing to the wide range of individual variation. A simple method of arriving at a result is to measure a series of cadavera, and then to remove, clean, and measure the limb-bones, when average values for the stature and for the length of each bone will be obtained. The quotient obtained by dividing the

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[1] *Mém. de la Société d'A. de Paris*, Tome IV. p. 347.
[2] *Chall. Rep.* XLVII., "Bones of the Skeleton," p. 103.

average stature by the average length of any bone, provides a coefficient for that bone, which will serve for the reconstruction of stature when the corresponding bone of a skeleton of unknown stature is to be investigated. The formula is thus as follows: Probable stature = Length (L) × coefficient. It is quite evident that this would give a very rough approximation only, for the stature obtained would be the average stature of individuals whose average bone-length had provided the coefficient used, and the individual stature might perhaps be very different from the average. Besides this, the coefficient is found to vary with the absolute stature, being different in short and in tall individuals, and also in the two sexes. Manouvrier[1] provided corrections for these errors which made closer approximations possible, and the coefficients are published in that author's monograph dealing with this subject. It is to be noticed that in these researches, it is postulated that the relation of the length of any bone to the stature is a simple one expressible by the formula

Stature = Length of bone × coefficient for that bone, or $S = L \times x$.

But later writers urge that the relation is not so simple, and that a more correct expression is given by the formula

$$S = L \times x + x',$$

and the value of both x and x' will depend upon various considerations, such as sex, race, absolute bulk, etc. Formulae of this latter type have been published by Pearson, and may be found in his contribution to the "Reconstruction of the stature of prehistoric races[2]." These formulae are similar to those provided for the determination of cranial capacity from the dimensions of length, breadth and height of the skull as described in Chapter XI.

Anthropometry. The foregoing method of investigating the characters of the limb bones so far as regards their proportionate lengths, is applicable with modifications to the living individual. The most interesting measurements in Anthropometry are accordingly those which provide a means of comparison of various individuals by means of the proportions subsisting between their

[1] Manouvrier, *Mém. de la Soc. d'Anth. de Paris*, Tome IV.

[2] Pearson, *Phil. Trans.* Part A, 192, pp. 109 *et seq.*

limbs and the different segments of the same. It seems appropriate to add in this place a brief account of the principal measurements to be made on living subjects. The instruments needed are (1) a long graduated rod such as is provided in Martin's traveller's anthropometric outfit, with (2) callipers, and (3) a head-spanner like those of Cunningham or Pearson[1]. The following measurements are recommended as of the first importance. The subject to be measured stands erect, and if possible the head is fixed, so as to bring the base-line (from the lower orbital margin to the upper margin of the external auditory meatus) into the horizontal plane.

A. The Head. (i) Horizontal circumference: measured as upon the skull: the maximum circumference in a horizontal plane being recorded.

(ii) Length: the maximum length, measured (as nearly as possible) as on the skull.

(iii) Breadth: the maximum breadth, measured as upon the skull.

(iv) Height: the basal height can only be arrived at by very special methods. Hepburn[2] has devised a special craniometer for the determination of this dimension. Ordinarily it is better to substitute the auricular height, measured as upon the skull, with the head-spanner.

B. The Face. (i) The nasal radius (or auriculo-nasal line): this is measured with the head-spanner, and is the distance of the nasion from the inter-auricular line.

(ii) The prosthionic radius (or auriculo-prosthionic line): this is measured with the head-spanner, and is the distance of the prosthion from the inter-auricular line.

From the two foregoing measurements, an indication of the prognathism (or the reverse) of the individual can be obtained: an alveolar index for the living subject may be constructed, substituting the prosthionic radius for the basi-prosthionic length, and the nasal radius for the basi-nasal length. Nelson Annandale (*Proc. Roy. Soc. Edin.* xxv. p. 12) has recently investigated the

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[1] Cf. Figs. 167 and 168.
[2] *Proc. Roy. Soc. Edin.* xxii. also Waterson, *Journ. Anat. and Phys.* xxxiv. p. 57.

relation between the radii (such as the basi-nasal and basi-prosthionic lines) drawn from the basion, with the inter-auricular radii, as measured with Pearson's head-spanner.

(iii)   The nasal length: measured from the line joining the eyebrows to the nasal spine, which can be felt subcutaneously.

(iv)   The nasal breadth: measured across the alae nasi: in laughter, this diameter is falsified and increased.

(v)   The facial height: from the line joining the eyebrows, to the prosthion, which is exposed when the upper lip is retracted.

(vi)   The facial breadth: the maximum bizygomatic breadth.

C.   The body as a whole.

1.   Height: the subject stands erect, the base-line of the head being in the horizontal plane.

2.   Height of chin: the subject stands as in No. 1.

3.   Height of pre-sternal notch: the latter is felt subcutaneously, the subject standing as in No. 1.

4.   Height of acromion process: this point is felt subcutaneously, the subject standing as in No. 1.

5.   Height sitting: the subject holds the head as in No. 1, and the buttocks are approximated to the measuring rod.

6.   Height kneeling: the head is held as in No. 1.

7.   Height of knee: measured to the lower margin of the patella, the M. quadriceps extensor cruris being contracted.

8.   Height of the internal malleolus of the ankle.

9.   Length of arm: from just below the acromion process, to the depression which is bounded above by the external epicondyle of the humerus: this gives the humeral length.

10.   Length of forearm: from the depression (mentioned in No. 9), in which the head of the radius can be felt; to the tip of the radial styloid process.

11.   Length of the hand: from the line joining the tips of the radial and ulnar styloid processes across the dorsum of the wrist, to the tip of the middle digit.

12.   Length of the foot: the maximum length, measured when the subject is leaning forward, so that the toes are not flexed.

'13.   Biacromial breadth: from one acromion process to the other.

14.   Bitrochanteric breadth : from the great trochanter of one side to the corresponding point on the other side of the body.

The foregoing measurements provide material for the construction of diagrams such as that which follows, which is drawn in comparison of similar figures published by Thomson in *Knowledge*. (Cf. Fig. 215.)
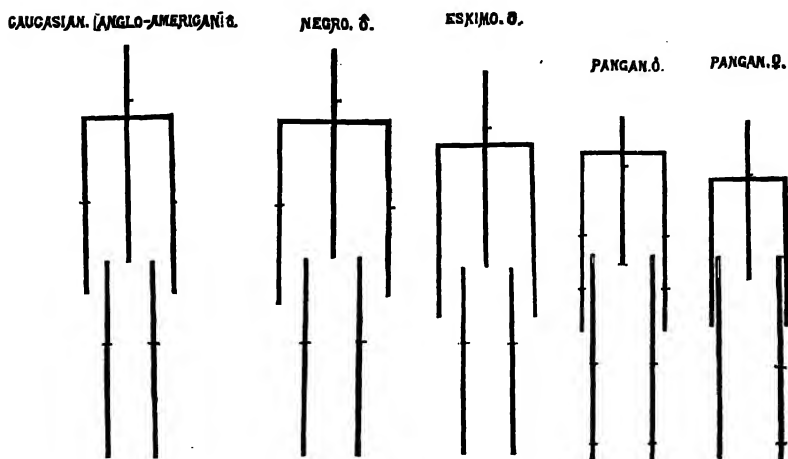
Fig. 215.   Diagrams showing relative proportions of average Caucasian, Negro, Eskimo, Pangan Semang (male), and Pangan Semang (female).

It will be noticed (with regard to the segments of the limbs), that whereas the humeral, radial, and tibial lengths can be ascertained with a fair degree of accuracy, the femoral length is very much more difficult to measure, and hence is represented only by the difference between the kneeling and sitting heights. But although the difference is not equal in amount to the femoral length, it nevertheless is an amount that will vary directly with the femoral length and therefore is useful from the point of view of comparisons.

CHAPTER XIV.

THE COMPARATIVE MORPHOLOGY OF THE SOFT TISSUES.

The Skin. From the skeletal structures, attention is now to be transferred to the soft tissues, among which the skin may conveniently be first considered. Next in order will be taken the hair and other dermal and epidermal appendages. Apart from the hair, the most important feature in the study of the cutaneous system is its pigmentation, with particular reference to the nature and distribution of the pigment. As regards the former subject, the pigments of the skin, though varying in nature in different races, agree in possessing certain characters in common, which lead to their association with other animal pigments in a group known as that of the Melanins (a generic name for epiblastic pigments). Melanin is regarded as the oxidised derivative of a colourless precursor called Melanogen; melanins are insoluble in alcohol, ether, and chloroform, but soluble in alkalies (and also in strong sulphuric acid. Sorby)[1]. They contain iron and sulphur in addition to the ordinary constituents of organic matter, but yield no definite spectrum. Melanins occur (in nature) principally in epiblastic structures, such as the skin, the hair, in the retina, especially in the choroid layer. These pigments appear to be functionally associated with the action of light, as is shewn by their constant (or almost constant) presence in dioptric mechanisms in animals, by the phenomena of sun burn, and of freckling[2]. But they also would seem related to degenerative processes, as exemplified by their presence in certain varieties of scars, in some cases of burns[2],

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[1] *Journal of the Anth. Institute,* Feb. 12, 1878.

[2] Baelz (*Z. für Ethn.* Bd. xxxiii., S. 204) gives some suggestive information on this subject.

in certain regions of the nervous system such as the sympathetic ganglia or the substantia nigra, where the association is presumably with vestigial structures which may be considered as degenerated if not degenerating; in the organisms of malaria[1]; and finally pigmentation is undoubtedly produced pathologically by such influences as certain toxic drugs, by altered metabolism, as in disease of the suprarenal bodies, or the production of cell-tissue of low vitality as in the case of melanotic sarcoma, in association with which growth melanin is excreted in the urine, to which it imparts a characteristic tint.

The action of the drugs which produce toxic pigmentation such as arsenic, is probably different from that of silver, for the latter supplies a main constituent of the pigment observed.

As arsenic has been shewn to arrest the glycogenic function of the liver (when given in pigment-producing doses) so that the "diabetic puncture" is no longer effectual, a suggestion is thus provided that the pigmentation may be derived from bile-pigments: certainly it appears that melanin may thus be derived, since it occurs in the urine in certain forms of malarial fever (black-water fever[1]).

The association of pigment formation (which may be extremely marked in cases of Addison's disease) with the suprarenal bodies, is still obscure. Tizzoni suggests that the normal action of the suprarenal bodies is to prevent pigment formation, and that the pigment appears when this normal function has been lost in consequence of the diseased state of those bodies.

Melanotic sarcoma most commonly originates in tissues in which pigment is plentiful, such as the choroid layer of the eye: but the secondary growths are characterized by the production of immense quantities of melanin in situations (such as the pericardium) in which its appearance is abnormal.

But it is necessary to return from this digression to the consideration of the occurrence and position of pigment in the skin.

The colour of the skin has been accepted from time immemorial as a distinctive racial character, and from the survey of osteological characters just completed, it will be seen that the distinction based

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[1] Melanin was first described in this connection, having been recognised in 1849. The names of Virchow, Frerichs, and Meckel are noteworthy in this connection.

on this test holds good in many features derived from at least one other anatomical system in addition to the cutaneous one. Many years ago Sorby[1] conducted researches on the varieties of pigment, finding three easily recognisable, viz.: a yellow pigment, a reddish-brown, and a black pigment. The so-called fair races normally possess so little of the two former varieties, that the pink coloration dependent on the superficial blood capillaries is hardly obscured: but exposure to light may increase the amount so as to obscure the normal pink tint, either universally as in ordinary bronzing from exposure to the sun or locally as in freckling.

In the yellow races, the two former pigments are normally present in such amounts as to obscure the presence of capillary vessels, and in the black races this effect is absolutely completed by the additional presence of the black melanin.

The pigment is usually confined to the lowest layers of the stratum mucosum, but in the black races may extend beyond this to a variable extent. Breul (*Morph. arbeiten*, Bd. VI. 3, quoted by Deniker) records the occurrence of pigment even in the corneous stratum, and on the other hand in the dermis: and Adachi (*Zeitsch. für Morph. und Anthropologie*, Bd. V.) also describes the wide distribution of pigment. Thomson remarks that the term "black" used in classifying races, is one of considerable latitude, for Sorby's results shew that (i) of two samples of hair of equal intensity of blackness, one may contain thrice the amount of pigment found in the second, and that (ii) certain samples of negro hair, while yielding abundance of black pigment, contained at the same time as much of the brown-red pigment as an equal weight of red European hair. For the present purpose, these conclusions from data relative to the pigment of the hair are applicable to the skin, the pigments being identical. In the black races the red pigment may be in excess and thus is explained the paradoxical occurrence of "red" negroes in the heart of the African continent, as in the Welle region (Fan and Nyam-Nyam tribes). Reddish hair has been noted among negro tribes, but care and discrimination are advisable before accepting statements of the kind, for the discoloration of the hair by means of lime is not uncommon among savage negro tribes.

[1] Sorby, *Journ. Anth. Institute*, Feb. 12, 1878.

The difficulties in the way of an accurate comparison of individuals of the more deeply pigmented races, are quite ignored by the current method of recording the colour of skin and hair: this consists simply in comparison with a numbered series of tinted sheets of paper, so that the observation takes the form of a numeral indicating the tint most nearly corresponding to the observed colour[1]. The method is arbitrary in the extreme, for the standard tints are limited in number to about forty.

The balance of opinion inclines to the view that the pigment is brought to the cells as such, and is not elaborated by them. The view has been advanced by Thomson (*Knowledge*, I. 2. 99) that the growth of the epidemic cells does not take place uniformly from the deepest layers upwards, but that the strata lucidum and granulosum are dividing layers, the cells of the former being the most superficially in direction, those of the latter being directed towards the Malpighian layer. But Breul's record (*v. ante*) of pigment in the stratum corneum seems to constitute an argument against Thomson's theory.

With regard to the distribution of pigment, it is to be noticed that even the fairest races present areas in which an accumulation of pigment is common, though the difference in intensity of pigmentation may be slight. Generally speaking, dorsal surfaces are more darkly pigmented than ventral surfaces, and particular regions such as the axillae, scrotum, perinaeum and the mamillae, are also characterized by darker tints which are not, as might be expected, diminished in intensity by protection from the action of light. The slighter pigmentation of the palmar and plantar surfaces in negroes is a matter of common knowledge.

Finally as regards the loss of pigment and the whitening of the hair, Metschnikoff's researches may be mentioned. This observer has shewn that the pigment in the hair shaft is removed by certain of the intrinsic cells of the hair which become actively pigmentophagic. (Cf. Metschnikoff, *Ann. de l'Institut Pasteur*, 1901, p. 865.)

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[1] The same objection may be urged against Rivers' method of rotating discs with sectors of varying shades. Thomson's suggestion is logical, but difficult to carry into practice: it is that (as regards hair) the amounts of pigments from equal weights of material should be compared. This process is protracted and needs reagents and chemical apparatus not easily transportable.

Following the method of procedure hitherto adopted, we may institute in the first place a comparison of the Simiidae with the Hominidae in respect of skin colour. In both primate families alike, variations in this respect are very pronounced; corresponding to the yellow and black human varieties, we may cite the yellow-skinned Simia (Orang-utan) and the black-skinned Hylobates or Gorilla. No exactly corresponding type to the fair-skinned Hominidae is in existence. Anthropopithecus niger (the Chimpanzee) demands a special notice: the distinctive adjective must be taken to refer to the colour of the hair rather than that of the skin, which in the young is yellowish, becoming freckled, with darker blotches, in the mature stages, while in aged individuals the freckles fuse (at any rate on the face) to form a uniform black skin: even in aged individuals, such fusion is often incomplete at the extremities, and an old Chimpanzee in the Cambridge Museum shews that the blotched condition may be retained throughout life. In contra-distinction to this, the skin of the Gorilla is uniformly black from the earliest post-natal stages known, though in the 5th-month foetus examined by Deniker[1] (the colour resembled that of "café au lait"), and in the younger ($4\frac{1}{2}$ month) foetus described by the writer, pigment had not yet asserted its presence in the skin. In these examples, a certain modification may have been produced by long sojourn in alcohol.

Within the Hominidae, the influences of age and sex can only be satisfactorily studied in the more deeply pigmented races.

The influence of Age. The newly-born infant of white parent-age is often characterized by an almost brick-red coloration, but though this might be claimed as a reminiscence of a pigmented phase in the ancestry of the white races, its occurrence may be also associated with the foetal mode of respiration and its effects on the tint of the blood. In reference to intermediate grades of pigmentation, it is a matter of some surprise that the offspring of white and black parents should so rarely be "piebald." Deniker cites instances[2] of the occurrence of temporary patches of pigment

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[1] *Thesè de Paris*, 1885.

[2] Baelz, *Mitt. deutsch. Gesell. Nat. und Völkerk. Ostasiens*, Vol. IV. p. 40; Matignon, *Bull. Soc. d' Anth. de Paris*, 1896, p. 524; Collignon, *ibid.* p. 528; Sören-Hansen, *Bidrag Vestgrönland. anthr.*, Copenhagen, 1893.

in the sacro-lumbar (dorsal), gluteal, or perinaeal regions in new-born infants amongst the Japanese, Chinese, Tagals of the Phillipines, and Eskimo. Still more recently, Lehmann-Nitsche has published (*Globus*, Band. LXXXV. No. 19), an exhaustive list of references, shewing the widespread occurrence of the phenomenon among the Hominidae.

With regard to the foetus, and even the newly-born child, among the Negro races, the opinion was long held that the characteristic colour was not present in those early stages. We may notice in this connection two researches, viz. that of Falkenstein, on the colour of the new-born infant in negro tribes; and that of Thomson[1] on the histology of the skin of the negro foetus. There seems no doubt that the negro infant at birth has not yet acquired the full intensity of pigmentation which it will subsequently assume. Falkenstein (whose observations were, be it remembered, carried out in the region of the Cameroons where a number of bronzed and even mottled negro types occur), notes that while the general colour of the newly-born infant is dusky red, not unlike that of some new-born white infants, yet at the same time, certain regions are already more distinctly and darkly pigmented. Such regions comprise (*a*) the dorsal surface in general, (*b*) the auricles, (*c*) the mammillae, (*d*) the region of the umbilicus. The same observer notices that the plantar surfaces are unusually light in tint, and indeed these, and the palmar surfaces, never attain to the same intensity of pigmentation even in the darkest negroes. Incidentally, it may be noted that the colour of the iris is not in that stage blue, as had been stated, but already brown, as in the later periods of growth. Falkenstein observed that in six weeks time, the true negro coloration was fully acquired, and thus the result differs from the observations of Pruner-Bey on negroes of the Soudan and lower Egypt, where one year and three years respectively were necessary for the full attainment of the character.

Thomson records the occurrence of pigment in the skin of foetuses of negro parentage, at ages from 5—8 months, and adduces Morison's evidence in support of these observations. It is remarkable that in the earlier stage (5th month) the pigment is more

[1] *Journ. Anat. and Phys.* 1891.

pronounced in the scalp, whereas at the 9th month no such predominance is observed.

Among other races, Chinese, Botocudos (Brazil), Malays, and Kalmuks are stated by Deniker (without specific references however) to be lighter at birth than in subsequent periods.

Sexual variation in pigmentation is a subject upon which more information is required before general statements can be made with confidence. While the general rule is that women are lighter in colour than men, thus possessing an infantile character (Deniker), notable exceptions occur, and cutaneous pigmentation has almost certainly some relation, though in nature obscure, with the functions of the genital system in females of white races.

Racial Variation. Finally we come to the racial factor in the distribution of pigmentation among the Hominidae. We have already noticed the distinction of the three main varieties of pigmentation, and remarked that other distinctions of a morphological nature accompany this (which might quite possibly be considered of physiological origin). We must here notice certain marked exceptions to this statement. For if we examine all the negro races known to us, we find that some of the most intensely black individuals are literally only "skin-deep" negroes and that judged by their osteology, and as far as is known their morphology as a whole, they are associated with races of white colour. As instances, the ebony-black Bishari tribes of the Soudan (closely associated geographically with the Soudanese negroes), and certain Abyssinian "Hamitic" tribes may be adduced.

Again, judged by the test of skin-colour, the Bush natives of South Africa would be associated with the Yellow races; but in the Bush native, these, which may be called Mongolian affinities, are also skin-deep only, and otherwise the general evidence of morphological conformation assigns to that race a most definite and almost isolated position, which is not adjacent to those occupied by yellow races.

Used alone therefore, the test of colour will lead to serious misapprehension of the real relations of various races, and tempting though its application is, it must, for the above reason, be relegated to a secondary position in the list of test-characters adopted in the attempt to classify the Hominidae upon a morphological basis.

With the remark that in colour-classification we may recognise three groups with the oldest observers, five groups with Blumenbach, ten with Topinard[1], or about forty with Broca, we must now turn to the consideration of the characters of the hair.

The Hair. A comparison of the hairy covering in the Simiidae and Hominidae reveals at once two striking facts: (a) the reduction in the extent of the hair-clad surface in the Hominidae[2], and (b) the no less remarkable sexual difference in the Hominidae, which is not observed in the Simiidae with the exception of Simia. The latter (the Orang-utan) presents us with the example of the greatest development of the hair, if we consider its general distribution, while at the same time this animal often shews a lack of the characteristic human feature of the development of the hair over the vertex of the head; a character shared by certain varieties of Chimpanzee, but not by Hylobates nor by Gorilla. Hylobates differs from the other three members of its family in respect of the direction of the hair-tracts of the upper extremity[3] which are

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[1] The ten varieties proposed by Topinard may be enumerated as follows:

A.	White	1.	pale, as in many Europeans.
		2.	florid, as in Scandinavians.
		3.	olive-white, as in Italians and Levantines.
B.	Yellow	4.	clear yellow, as in Chinese and probably in Bush natives.
		5.	olive-yellow, as in Polynesians.
		6.	dark yellow, as in Malays.
C.	Dark	7.	coppery-red, as in Nyam-Nyams.
		8.	chocolate-brown, as in aborigines of Australia.
		9.	sooty-black, as in African negroes.
		10.	coal-black as in Bisharis, and Oceanic negroes, as well as African negroes.

[2] Cf. Flower, Romanes, also Kidd, *Journ. A. and P.* Vol. xxxv. p. 305. In the latter paper (upon the direction of the hair-tracts) Kidd suggests that Voigt's theory (that the determining factor is the growth of the skin, which occurs unevenly in different directions at various periods), is less probably correct than the explanation which calls to account the action of gravity, combined with the effect of habitually-repeated movements pressing the hair into the several tracts observed.

[3] This reduction of the hairy covering is not so uncommon among Mammals as might at first appear. Thus the order Cetacea is characterized by the complete absence of hair among its members, if we exclude baleen from that designation. Many Ungulata, such as Elephas and Hippopotamus, are hairless or nearly so: the Sirenia are almost hairless, and so are certain Edentata, Cheiroptera, and Carnivora. Absence of hair and hair-follicles from the terminal phalanges of the digits was recognised by Romanes as a distinctive "ordinal" character of the Primates. Cf. *Life of Romanes*, p. 297. (*Letter to Schäfer.*)

uniformly directed towards the wrist, whereas in the other Simiidae and in Hominidae convergence on either side towards the elbow is found. In the Simiidae and Hominidae alike, hair-tracts diverge from the knee, passing up and outwards on the outer surface of the thigh, down and outwards along the outer surface of the leg. There is (with the above-mentioned exception) a very general agreement between Simiidae and Hominidae regarding the disposition of hair-tracts and vortices (for further discussion of these cf. Wiedersheim, *Structure of Man*, Engl. trans. pp. 4 *et seq.*)[1]. Within the Hominidae, the influences of age, sex, and race will now be considered.

The foetus, at the later stages (e.g. the sixth month) of intra-uterine development bears the extensive lanugo-covering, which is, however, shed before birth, so that the newly-born child is to all appearance almost entirely destitute of hairy covering: the hair on the head is short and soft, and a close inspection will usually lead to the detection of a fine down-like hairy covering which is very general over the surface of the body.

Sexual differences in the hairy covering demand but scanty notice here: and we may notice that the familiar sexual difference observed in the white races is noticed generally in the Hominidae. Sporadic examples occur (among the white races) of unusually hirsute females, especially perhaps among the brunette races of Southern Europe, but this cannot be claimed as a trait allying the races in question to the black races, in which this feature is not as a rule pronounced. Age seems to have some influence, and occasional instances of excessive development of a beard, even surpassing that normal in males, are on record as occurring in females of white races, but such instances are commonly regarded as verging on pathological varieties.

It seems appropriate in this connection to call attention to the not uncommon occurrence of long tufts of hair growing from pigmented naevi or "moles." Such instances are associated with some local deviation from the normal course of development, and are not distinctive of sex or race. Bland Sutton quotes cases of the association of long tufts of hair with imperfect closure[2] of the

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[1] For further researches on the direction of hair-tracts, see various papers in the *Proc. of the Zool. Society* by W. Kidd, F.Z.S. 1899 *et seq.*

[2] See also Mayet, *Z. für Ethn.* Band 33, s. 426, on sacro-lumbar hypertrichosis

neural arches of the vertebral column[1]. Similar trophic aberrations may be called in question to explain the occasional excessive hirsuteness of individuals of feeble intellect.

The ordinary racial variations in the extent and the distribution of the hair are so well known as to call for merely a brief recapitulation here. The range of variation is extreme: on the whole the yellow races are the least hirsute: to these the black races come next in order (with some remarkable exceptions), and the white races must be reviewed to discover the examples of the highest development of this character. These remarks apply not only to the hair of the head but also to the hair of other regions, such as the axillae and pubes[2]. The hair when abundant is usually more plentiful on the anterior (ventral) than on the dorsal aspect: but occasionally one may see examples of white men with an abundant crop of hair over the scapular regions.

The excessive hairiness of the Ainus, or Ainos (the aboriginals of the northern islands of the Japanese group) has long been notorious. It may be mentioned that these aborigines are associated by the characters of the hair, as well as in certain other respects, with the white races, rather than with their Mongolian neighbours[3].

The aborigines of Australia present the extremes of hairiness and its reverse, for while Miklucho-Maclay[4] has recorded the existence of practically glabrous natives in Australia, the explorations of Spencer and Gillen[5] have revealed the presence of individuals rivalling the Aino in hirsuteness. The Todas of Hindustan may be cited as further instances of pronounced hirsuteness in darkly-pigmented races.

The dwarf races as a rule retain the infantile character of

as a sign of degeneracy. Many references are appended. In the same volume, Baelz discusses the hirsuteness associated with cachexia (*ibid.* p. 209).

[1] *Evolution and Disease*, p. 23.

[2] Cf. Strauch, *Z. für Ethn.* Band 33, s. 534.

[3] Recent researches, summarised by Koganei, shew that there is a good deal of reason for regarding the Ainos as having been present in the Japanese region since the neolithic period. Cf. Koganei, *Mitt. der Deutschen Ges. für Nat. und Völkerkunde Ostasiens*, Bd. IX. Teil 3, abstracted in *Man*, 1903. Baelz, *Z. für Ethn.* Band 33, s. 209, states that the Ainos retain the lanugo much longer than Europeans.

[4] *Sitz. der Berlinder Anthrop. Gesellschaft.* Ap. 16, 1881.

[5] *The Native Tribes of Central Australia.*

feeble development of the hair, but while the Negrito races of Asia conform to this rule, exceptions occur among the dwarf tribes of Central Africa, which in this respect provide the type of gnome familiar in legend and folk-lore[1]. The so-called hairy men from time to time exhibited in various parts of the world (well-known examples are of Russian and of Burmese origin respectively) are to be regarded as having retained an embryonic condition: in such instances the lanugo is supposed to be persistent and fully developed, and the tendency to inheritance of the character is strongly marked. As regards records of hairless men, a word of warning must be given as to the acceptance of reports of explorers or travellers before the exclusion of the possibility of epilation, or artificial removal of hair has been considered. The practice is widely spread, and well authenticated as in vogue among certain of the natives of Tierra del Fuego (probably the Yahgans; cf. Darwin's *Journal*).

Other characters of the hair than its abundance and distribution now claim attention. As a rule the hair is longest where it is most plentiful. In some races the hair of the head compensates as it were, by its exuberant growth, for its poverty of development elsewhere. The extraordinary length of the hair of the head in both sexes among certain Indian tribes of North America is an example in point. The form of the hair finally remains to be mentioned. Speaking generally, the varieties usually recognised are, (1) straight or wavy, (2) woolly; and so distinct are these types that they have been used as morphological tests in the classification of the Hominidae. In illustration of this application no better example can be adduced than Huxley's classification[2], in explanation of which the author remarks that " In attempting to classify these persistent modifications (or *stocks of mankind*) after the manner of naturalists, the first circumstance that attracts one's attention is the broad contrast between the people with straight and wavy hair and those with crisp, woolly, or tufted hair. Bory de St Vincent, noting this fundamental distinction, divided mankind accordingly into the two primary groups of *Leiotrichi* and *Ulotrichi*—terms which are open to criticism, but which I adopt in the accompanying table, because

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[1] Sir H. H. Johnston, *The Uganda Protectorate*. Lanugo-like down covers the bodies of the Uganda dwarfs.   [2] *Man's Place in Nature*, edit. 1894, p. 235.

they have been used....Under each of these divisions are two
columns, one for the Brachy-cephali
or short heads, and one for the
Dolicho-cephali, or long heads.
Again each column is subdivided
transversely into four compart-
ments...," the latter corresponding
to different shades of colour of
the skin.   That part of Huxley's
classification with which we are
here concerned may be thus re-
presented.

	Leiotrichi		*Ulotrichi*	
	Dolicho-cephali	Brachy-cephali	Dolicho-cephali	Brachy-cephali
Leucous				
Leucome-lanous				
Xanthome-lanous				
Melanous				

Here then we see the form of
the hair used in the first rank of
morphological criteria[1].

Since Huxley adopted Bory de
St Vincent's classification, a fur-
ther division of the varieties of
hair has been suggested and the
three following groups are now
recognised.

   (*a*)   Straight.
   (*b*)   Wavy.
   (*c*)   Curly.   (Cf. Fig. 216.)

But the morphological differ-
ences in the hair go beyond these
superficial appearances: for with
the most curly or frizzled varieties
is associated a peculiarity of im-

Fig. 216.   Bush-woman of South
Africa.   The characteristic features of
the hair of the head, and the accumu-
lation of gluteal fat (steatopygia) are
evident in this individual.

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[1] It has been displaced in later classifications, largely in view of the prominence
given in these to brain development as evinced by cranial characters.

plantation most evident in the hair of the head; it consists in the segregation of the hair into groups or islets, separated by bald areas: the appearance is described as "pepper-corn," the hair seeming to be attached in small discrete groups, each group containing a number of tightly coiled hairs in the form of a ringlet: the best examples occur among the aboriginal races of Africa, among which, and especially in the Bush race, the character has reached the acme of development.

Again, the form of the hair, as seen when transverse sections are viewed microscopically, provides an important means of distinction. While such sections, if taken from near the free end of the hair, are in almost every instance circular in contour, this feature is only retained throughout the length of the shaft by hair which is macroscopically straight or lank: in the wavy, and to a still greater extent in the curly, varieties of hair, the circle is replaced by a contour of elliptical proportions. The more frizzly and tightly coiled the hair, the flatter will be the ellipse, and the comparison has been justly instituted with a wood-shaving, with which such hairs agree in curliness and in flatness of section.

Micrometric measurements provide a means for determining an index of the section, from the formula:

$$\text{index} = \frac{\text{breadth of the section} \times 100}{\text{length of the section}};$$

and the numerical value of this index has been found to vary between 28 and 100[1], the lowest figure being provided by the curly hair of an Oceanic negro (Papuan), and the highest by the lank and straight hair of Mongolians. The form of the hair (in transverse section) of a (negrito) Semang of the Malay Peninsula is represented in Fig. 217: it is to be noted particularly, that in even curly hair the form of the section near the free end of the hair tends to reproduce that of a circle, though nearer the root this circle is replaced by an ellipse.

In association with this feature of flatness of the hair-shaft is found a peculiarity of the hair follicle, for such hairs are not implanted in the skin in a direction so nearly vertical to the

[1] Pruner-Bey, *Mém. de la Soc. d'A. de Paris*, t. II. p. 78, t. III. p. 1.

surface as are wavy and straight hairs: but, as was pointed out by Professor Charles Stewart of the Royal College of Surgeons, the frizzly hairs emerge very obliquely to the surface, and in a section of the skin the hair follicle is found to be strongly curved: the curvature is already present in the hair follicles of the scalp of the negro foetus at 5 months[1]. Within the concavity of the curve is an extensive sebaceous gland, whose situation in relation (*a*) to the hair and (*b*) to the erector pili muscle, suggested to Thomson[1] that the hair follicle may have become bent round the mass of the gland under the strain exerted by the smooth muscle-fibres when in action. This view has much to recommend it, and in default of a more reasonable hypothesis is recognised as holding the field.

The pigment of hair is similar to the pigment of the skin, which has been already commented upon. In sections, the pigment appears aggregated (*a*) in the central portion or medulla of the hair, though Kölliker (*Handbuch der Gewebelehre*, 1889, p. 228) points out that air bubbles in this situation may simulate pigment-cells; and (*b*) peripherally; with a clearer intermediate zone. (Cf. Fig. 217.)

The curious phenomenon of the hair turning white in aged negroes, while the general colour of the skin is unaltered, still awaits explanation, though Thomson[1] has attempted this, on the basis of his theory of the direction of growth of the intermediate layers (strata lucidum and granulosum) of the skin.

We have seen that a general review of the characters of the hair shews that three principal forms are recognisable: the straightest variety, with a straight follicle and circular form in section is found to be associated with the slightly pigmented skins of yellow races

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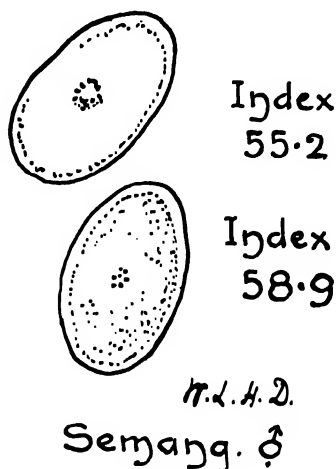
Semang. ♂

Fig. 217. Two sections of scalp hairs of a (negrito) Semang from the Malay Peninsula. (Skeat Exped.; Mus. Anat. Cant.)

[1] A. Thomson, *Knowledge*, Ap. 1899.

whose general status is intermediate between the extremes of the white and black races. The white races present all forms of hair, save the extreme varieties of the frizzly type, and in general, frizzly or very curly hair is usually a mark of negro (or negrito) admixture or descent: in the negro, the hair is scanty, the beard minimal, the hair peculiarly distributed on the head, the section a flattened ellipse, and the follicle strongly curved.

With regard to colour, the extreme types (as regards form) of hair nevertheless agree in being black, the curly varieties of hair being almost invariably of this shade: the intermediate varieties may in the white races present the various shades of colour familiar in Europeans, but the wavy hair of the Veddahs of Ceylon, of certain aboriginal tribes of Madras, of Sakais of the Malay Peninsula, and of aboriginal natives of Australia resembles the curly hair of negro races in being black. The pygmy races of Central Africa are characterized by the dull grey or greenish-brown colour of the scalp hair: the frontal hair is lighter in tint than that further back[1].

The cutaneous glands and subcutaneous tissues. The large size of the sebaceous glands in the Bush race and negro races of Africa has been incidentally mentioned. With regard to the mammary glands, the chief points to notice refer to their form, and the maintenance of this after pregnancy. Ploss[2] has classified the external form of the breast as represented by various human races, but the classification is of little value from the point of view of comparative morphology[3].

The greater size of the mammilla may be claimed as a simian character of the negro races. But it seems probable that the characters of the breasts are the outcome of modifying influences of secondary importance. This brief note may be terminated with a reference to that character of men of certain South African negro (Zulu and other allied) tribes which has been described as Lobengulism. This development of the subcutaneous tissues is very conspicious in the natives referred to, but there is no

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[1] Sir H. H. Johnston, *The Uganda Protectorate*, Vol. II.   [2] *Das Weib.*

[3] Baelz, *Z. für Ethn.* Band 33, s. 219, discusses the relation of the so-called "Supra-mamma" to vestigial supernumerary mammae.

information accessible to shew exactly which tissue the hypertrophy in question has affected.

The steatopygia or gluteal hypertrophy of African negro races reaches its maximum in the (yellow) Bush-woman. In this case the gluteal mass (cf. Fig. 216) is found to consist of fat and connective tissue overlying the M. gluteus maximus. While the phenomenon may be due to secondary sexual modifications, one notes a certain degree of the same character even in the male sex, viz. in Bush-men, and the suggestion that this gluteal development may be analogous to the hump of the camel, the gluteal fat of certain sheep, the caudal fat of certain Galagos (Lemuridae), and of certain desert-inhabiting Mammals (Marsupials) of Central Australia, does not seem altogether unworthy of investigation, especially when it is remarked that the Bush pygmies inhabit desert-wastes like the Karoo, which prove their only refuge against stronger and larger neighbours.

The Eyes. Three main divisions of eye-colour can be conveniently adopted, viz. light, intermediate, and dark.

Light-coloured eyes include blue and grey eyes.

The intermediate group includes green, greenish-grey, hazel, and the lightest brown eyes.

Dark eyes are brown, of shades other than the very lightest.

The latter eyes are most similar to those of the Simiidae, and indeed the Anthropoidea in general; and among the human races very dark eyes are accompanied by an indication (sometimes in the form of isolated patches) of the pigmentation of the sclerotic so common in the lower Primates, and in the lower Mammalia.

The eyes, like the hair, of the human child tend to become darker with progress in age.

With regard to the distribution of eye-colour among the various human races, eyes of the first class (blue and grey) occur among the white races: the same remark holds good for the second class with the possible exception that some yellow races are said to possess very light brown eyes[1]. But the great majority of the yellow races and all the negro races come into the third class,

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[1] Deniker, *The Races of Man*, p. 49.

having eyes of a dark brown shade of colour. The white races also come into this category.

From the foregoing remarks it appears that the colour of the iris is not a very satisfactory means of classification, and in fact it is employed rather as an accessory than as a primary criterion.

But in connection with the eyes certain other morphological characters may be mentioned. Pruner Bey[1] suggests that the ocular globe in the negro races is larger than in the white races: the plica semilunaris is said to be less vestigial in the black races; Giacomini[2] found remnants of cartilage in this region in a Bush native of S. Africa, and also an accumulation of glandular cells similar to those observed by him in Cercopithecidae, and identified with the Harderian gland of lower mammals. Further, the circular ciliary muscle is largely developed, suggesting slight hypermetropia, which indeed from the observations of Callan[3] seems to be normal in negro races. Another point in this connection is the effect of the form of the orbit on that of the ocular globe and consequently on vision. If the orbit is flattened, i.e. micro-semic (chamae-conchic in the terminology of German writers), the vertical diameter of the eyeball will be small, and probably its sagittal diameter will in compensation be relatively long. An eyeball with such proportions is liable to be myopic, though it is stated that the rarity of myopia among the Finns and Esthonians is detrimental to this theory[4].

The " Mongolian " eye is characterized by the narrowness, and by the obliquity of the rictus oculi, as well as by the cutaneous fold which crosses the inner angle of the eye, obscuring the caruncula lacrymalis[5].

This cutaneous fold (cf. Fig. 218) is associated with imperfect development of the nasal bones in the white races, and this is not

[1] Quoted by Hamy and Hovelacque, *Précis d'A.* p. 309.

[2] *Annotazioni sopra l'anatomia del negro*, 1878, 1882, 1884.

[3] *American Journal*, Ap. 1875.

[4] Cf. Swanzy, *Handbook of Ophthalmic Surgery*, and reference in Chapter XI. page 268.

[5] This skin-fold is to be clearly distinguished from the plica semilunaris, which is much more deeply situated. A recent contribution to the extensive literature on this subject was made by Baelz, *Z. für Ethn.* Band 33, p. 187. The plica semilunaris is frequent, and contributes to the Mongolian appearance of the eye, in certain idiot children (cf. inter alia, Ireland, *Mental Affections in Children*, p. 57).

infrequent in European children, disappearing as the nasal bones gain in prominence. It is thus probable that the permanently smaller nasal bones of the yellow races, in which this fold is present (many Chinese are exceptions, as also most of the American races) is responsible for the condition, though it is noteworthy that the negro races in which the nasal bones are flatter and smaller than in Mongolians are not thus characterized: but Testut[1] states that the fold occurs sporadically among the Hottentots.

Fig. 218. Diagrams of the appearance of the eye. (A) normal, (B) epicanthus, the epicanthic fold (P) giving rise to the appearance known as that of the Mongolian eye.

The choanoides muscle or M. retractor oculi is constant in the Cercopithecidae and lower Mammals. Chudzinski has recorded it in negroes; this occurrence may be claimed as evidence of the lowlier status of the pigmented races.

The Ears. The racial aspect of the anthropology of the external ear still awaits investigations capable of leading to definite general conclusions. In the Simiidae and Hominidae alike the external ear is degenerate as compared with its condition in the lower Primates, still more in the lower Eutheria[2]. Within the Simiidae, variations in form occur, the Orang-utan and Gorilla having small ears, the Chimpanzee differing from both in the possession of large ears. Even among Chimpanzees a considerable degree of variation is possible, and the size and proportions of the ear have been used as a means of differentiating several varieties of this animal. Among the Simiidae the external ear is in general form very similar to that of the Hominidae: apart from the actual size, the proportions (as expressed by an aural index $=\dfrac{\text{breadth} \times 100}{\text{height}}$) shew that the Simiidae approach rather nearer the generalized Mammal in the possession of a wider auricle, with a correspondingly higher index. Two descriptive points remain

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[1] *Anatomie humaine*, tome III. p. 228.

[2] Chudzinski (*Les muscles peauciers*) remarks that the external ear is usually degenerate in animals possessing a well-developed clavicle.

for notice. (*a*) The margin of the helix is, in the Simiidae, thin and it is not rolled over so completely as is normal in the Hominidae. In the latter, then, a thin and unrolled helical margin is a simian feature. (*b*) The lobule is by some said to be non-existent in the Simiidae: but it is not always absent, though even when it is present it is not detached from the side of the head as in the perfect human form. A "soldered" lobe in the Hominidae is therefore to be regarded as a simian character.

Within the Hominidae it is to be noticed that in general the ear is larger and projects further from the head in man than in woman: a measure of its projection was devised by Frigerio (the auriculo-temporal angle[1]). The angle at which the auricle is set on the head is included by the base line of the head (from the inferior orbital margin, to the superior margin of the external auditory meatus), and the long axis of the auricle: marked obliquity is observable when this angle exceeds 112° (Schwalbe[1]). But no general statement can be made on this subject, so far as the influences of age, sex, or race are concerned. Long after maturity a recrudescence of growth is noticed in the auricle, which increases in size in the later years of life.

With regard to racial differences in the form of the ear we may notice that Rauber[2] states that the aural index (*v. infra*) is least in the yellow races, intermediate in the white, and greatest (i.e. most Therian) in the black races. Herein Rauber is probably following Topinard[3], who makes a similar statement with regard to the yellow races, but it is to be noted that a single example only is adduced.

Topinard's data are here appended: from these it appears that the aural index possesses a zoological as well as an anthropological significance.

$$\text{Aural index} = \frac{\text{breadth of auricle} \times 100}{\text{height of auricle}} :$$

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[1] Cf. Schwalbe, *Archiv für Psychiatrie*, 1895.

[2] *Anatomie des Menschen*, Leipzig, 1897, Band II. p. 774.

[3] *Él. d'A. gén.* p. 1004.

No. of observations	Hominidae				Index
1 ...	Mongol			...	51·4
8 ...	Whites (average)			...	54
13 ...	Negroes „			...	61
8 ...	Melanesian Negroes (average)			...	59·5
3 ...	Polynesians (average) ...			...	60
	Simiidae				
2 ...	Gorillas (average)			...	69·1
3 ...	Chimpanzees (average) ...			...	71·1
1 ...	Orang-utans (average) ...			...	85·1
	Cercopithecidae				
1 ...	Cynocephalus			...	62·
1 ...	Cebus			...	81·
1 ...	Macacus			...	88·
1 ...	Cercopithecus			...	90·5

The writer has made several observations[1] upon specimens in

[1] Aural Indices	Right ear	Left ear
Hominidae.		
Kroo negro ♂	57·3	52·8
Australian aboriginal ♂	44·1	43·2
„ „ ♀	50·7	54·8
European child (7 yrs.)	62·2	65·9
European human foetus :		
(1) Early fifth month	78·9 (?)	66·6
(2) „ „ „	72·2 (?)	55·5
(3) „ sixth „	56	50·8
(4) „ ninth „	80·6 (?)	83·3 (?)
Simiidae.		
Gorilla ♂	?	70·6
Chimpanzee	72·7	83 (?)
„	77·2	78·3
Cercopithecidae.		
Macacus monkey (1)	96·8	93·7
„ (2)	75	87·1 (?)
„ (3)	77·1	77·7
„ (4)	65·7	78·7
„ (5)	93·3	84·8
Cercopithecus monkey	92	85·1
Cebidae.		
Cebus monkey	81·8	78·7
Chrysothrix sciureus	79·1	83·3
Lemuridae.		
Lemur varius	74·2	74·2

the Cambridge Museum, from which the general indications corro-
borate the conclusions of Topinard. But the variability of the
character is marked, for the aboriginal of Australia provides an
index numerically lower than that of the Mongol in Topinard's
list, while a human foetus (European) at the ninth month is quite
out of place.

But Topinard further mentions that in point of size the auricle
is greatest in Melanesian negroes, then in Polynesians, least in the
yellow races, the length of the ear providing a similar seriation.
The African negroes however, to judge from my own observations,
frequently possess a small and almost delicately-formed external ear.

Absence of the lobule is said by Topinard (*op. cit.* v. p. 364,
supra) to occur with unusual frequency among the Berbers of
North Africa and among the Cagots of the Pyrenees.

While the requisite evidence for establishing morphological
generalisations of wide application is thus scanty, it is quite
otherwise as regards the more limited range of the white races;
much labour has been expended in observing ear-forms, more
particularly in relation to social environment, and the investigation
of the suggested "criminal-type" of external ear. So for instance
Gradenigo (quoted by Schwalbe[1]) submits that the following
features characterise criminals and lunatics.

1. Great projection of the auricle from the side of the head.
(It may be noted that this is not a character of the black races,
nor of the Gorilla or Orang-utan, though very conspicuous in
the Chimpanzee. W.L.H.D.)

2. Lack of inrolling of the helix.

3. Prominence of the anti-helix.

4. Prolongation of the lobule on to the check.

5. Presence of an elongated depression on the lobule (viz. the
scapha continuous with the sulcus supralobularis, or lobe traversée
of Bertillon).

But even so, these matters are far from final settlement, and
will consequently be passed over without further comment, a
list of some of the more important papers on the subject being
appended[1].

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[1] Warda, *Archiv für Psychiatrie*, 1899, xxxii.; C. U. Lib. xxvii. 54, 132. Schwalbe,
A. für Psych. Vol. xxvii. 1895; Gradenigo, *A. für Ohren-heilkunde*, xxx. 1890, s. 230;

The Nose. The nose is a distinctive feature of the human physiognomy, for although Hylobates (Simiidae) has a quite recognisable nose this is far from having attained the prominence of the human organ. Among the Cercopithecidae, certain monkeys, such as the Nasalis and Roxellana apes, have well-developed noses, and in old male Nasalis monkeys the organ may be grotesquely exaggerated in size. (Cf. Fig. 27.)

But even here the parallel is inexact, for the nose in Nasalis larvatus is a mere mass of connective tissue, which lacks the comparatively elaborate skeleton of the human nose.

Among the Hominidae, the full size of the nose is attained late in the post-natal period, and indeed progress in growth coincides with the recrudescence of facial development noticed at puberty. The nose of the infant is flat and wide; these characters are retained throughout life in the yellow and in the black races, and to some extent in females in the white races. The nose thus attains its greatest development among male members of the white races. With regard to proportions, the infantile features are, as previously mentioned, flatness, with considerable relative breadth as measured across the widest portion of the nose. A nasal index for the external nose has been devised, whereby the breadth and height of the nose are compared, just as for the nasal index in the skull, a comparison of the corresponding dimensions of the apertura pyriformis nasi is instituted. In the living subject (cf. *Anthropometry,* Chapter XIII. p. 344)[1] the nasal index is derived from the formula, index $= \dfrac{\text{nasal breadth}}{\text{nasal length}} \times 100$.

But the numerical value of the index is very different in the skull and on the face: for the latter the limits taken are 70 and 85. Up to 70 then, leptorrhine is the term applied; from 70 to 85 inclusive, mesorrhine; and over 85, platyrrhine.

Z. für Ohren-h. xxii. 1892, s. 179; *A. für Ohren-h.* xxxii. and xxxiii. Vali, *A. für Ohren-h.* xxxiv. 1893. Daae, *Z. für Ohren-h.* xxiv. 1893, s. 288. Warda, *Degenerate Ear-forms...Neurol. Centralblatt.* 17, 1898, s. 526. Ganter, *Archiv für Psych.* xxxviii. Heft 3, s. 998, found that 55% of a series of lunatics presented aural anomalies.

[1] The maximum breadth is simple to measure, but the nasal height is not so easily determined; the nasal spine is not difficult to find, but the situation of the nasion is often obscure; Topinard explains that it corresponds in level with the lower of two transverse grooves commonly found traversing the nose about the level of the eyebrows, and this guidance is the best available at present.

Deniker[1] gives an exhaustive list of these indices, which range from 60·4 in the white races (Armenians), to 107·9 in West African negroes. The same writer (*op. cit.* p. 80) notes that noses may in profile provide the following appearances:

(1) Straight or slightly sinuous (white races and certain yellow races).

(2) Concave: typically seen in some aborigines of Australia: also in the Bush natives, in Lapps and Finns.

(3) Convex and sometimes arched: white races (Jews) and American aborigines.

The characters of the nose in infants of white race and the resemblance borne to the nose in adults of other races have previously been described (Chapter VII.).

The Mouth. The conformation of the lips affords a means of distinguishing various human races, for the lips are finest and least prominent in the white races, coarsest, projected and everted in the negro races (especially African negroes), the yellow races occupying in this respect an intermediate position.

The Teeth. A general survey of the characters of the teeth is provided in Chapter VI. (*q. v.*), and in the present connection comparison will be confined within the limits of the Hominidae[2]. The possession of an ample palate and large well-formed teeth by the black races is a matter of common knowledge (as is the fact that in the crania of the prehistoric inhabitants of Europe the size and quality of the teeth, were superior to those at present obtaining in the same geographical area). It is therefore impossible to overlook the inference that reduction in the size of the teeth is at least attendant (if not dependent) upon the acquisition of higher grades of civilisation and directly upon diet and the preparation of food.

As a means of comparison, the dental index devised by Flower[3]

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[1] *Races of Man*, Appendix III.

[2] Ethnic deformation of the teeth must be mentioned here. The nature of the deformation, which usually takes the form of filing, or violently extracting one or more teeth, is as a rule easily recognisable. Crania from New Guinea in the Cambridge University Collection bear the teeth of pigs, substituted posthumously for the original teeth.

[3] *Journ. Anthr. Instit.* 1885.

is noteworthy, and it will be explained in the section dealing with the molar teeth.

Turning again to the dental variations among the Hominidae, and particularly to the incisor teeth, we may notice the records[1] of enormous teeth of this description in the Admiralty Islanders, who are of Melanesian or Oceanic-negro stock. Such teeth are commonly spatulate, i.e. their lateral margins are divergent towards the free extremity. The condition is well shewn in the incisor teeth of an aboriginal native of Australia in the University Museum (*v.* Fig. 107) and it has been remarked as a feature of the incisor teeth of negroes by Regnault (*Soc. de Biologie*, 1893). The spatulate incisor is typical of Nesopithecus. (Cf. Chapter XVII.)

An interesting point regarding the incisor teeth was brought out by Turner[2], who remarked that among the prognathous aboriginal natives of Australia the upper incisor teeth do not overlap those of the mandible in front when the jaws are closed, but that the teeth of the upper and lower series bite edge to edge. A similar observation had long before been made relatively to the crania of Greenlanders and to crania of prehistoric date found in Denmark[3]. The condition is not constant in any of the groups mentioned, but its significance is undoubtedly great. For it indicates that the reduction of the mandible is not so great (in such individuals as present the character) as in instances of overlap. The condition is clearly illustrated by Turner in the memoir referred to.

The tendency to suppression of the lateral incisors in the white races has been already mentioned. This tendency, it may be remarked, is more pronounced in the upper jaw than in the mandible.

The canine teeth present few striking anomalies beyond greater development in size in the megadont Hominidae.

The pre-molar and molar teeth are measured in the computation of Flower's dental index, as derived from the formula:

Index

$$= \frac{\text{combined length of crowns of pre-molar and molar teeth} \times 100}{\text{basi-nasal length}};$$

[1] Cf. Miklucho-Maclay. *Zeits. für Ethn.* Bd. VIII. 1876, Pl. XXVI.
[2] *J. Anat. and Phys.* Vol. XXV. [3] Cf. Lubbock, *Nat. Hist. Review*, 1860.

and upon the numerical values of this index a classification has been based in the following way:

Crania in which the index falls short of 42, are microdont.

Crania in which the index is from 42 to 44 (inclusive), are mesodont.

Crania in which the index is above 44, are megadont; and the illustrations following, which are taken from Flower's memoir, afford a good demonstration of the greater size of the teeth in the negro-races.

Microdont Hominidae: index below 42.

Europeans, prehistoric Egyptians, Polynesians, low-caste natives of Central and Southern India.

Mesodont Hominidae: index 42 to 44 (inclusive).

Chinese, American Indians, Malays, African negroes: in the latter the value of the basi-nasal length is numerically very great, and hence their appearance in this class.

Megadont Hominidae: index above 44.

Melanesians, Andamanese, Australian and Tasmanian aborigines. For the teeth of aborigines of Australia in the University Museum an average index of 45·2 was obtained. Female skulls provide an even higher figure (49·25).

Finally the following data are of comparative value:

Gorilla (average index for both sexes)   54·1
Chimpanzee (average index for both sexes) 47·9
Orang-utan (average index for both sexes) 55·2
Hylobates: 1 example   41·7.
   (The latter is thus microdont.)

The number of cusps carried by the several teeth of the molar series has been counted in a great many instances, and the chief contributors to these statistics are Zuckerkandl, Röse, Topinard, and Tomes[1]. Zuckerkandl examined 542 crania; Röse 1241 maxillae, and 828 mandibles; Topinard, 595 crania; while Tomes does not mention the number at his disposal.

The general conclusions of the two first-named observers are in agreement, and to the following effect.

[1] Zuckerkandl, Scheff's *Handbuch der Zahn-heilkunde*, Bd. I. Röse, *Anat. Anz.* VII. Topinard, *L'Anthropologie*, 1892. Tomes, *Dental Anatomy*, 1898.

The normal number of cusps is four for upper molar teeth, and five for lower molar teeth.

The same general pattern obtains, both in European and non-European Hominidae, in both of whom the third molar tooth of the upper series has undergone more reduction than any other tooth. Such reduction is more active in European than in non-European Hominidae, and chiefly affects that cusp which has most lately appeared, viz. the postero-internal cusp (cf. Fig. 219. ·PI) so that a tendency to trituberculism is in progress.

Fig. 219. Diagram of a molar tooth of the right upper series. AE, antero-external cusp. AI, antero-internal cusp. PE, postero-external cusp. PI, postero-internal cusp. *x*, region in which small accessory cusps appear.

Tomes in turn gives a general assent to the conclusions of Topinard, who unconsciously confirms the foregoing earlier observations, and provides some statements of detail as follows:

The first upper molar tooth appears to be subject to but little variation in all Hominidae.

The second upper molar tooth bears four cusps in only 58% of highly civilised races, and in 80% of primitive races, such as the Malays and Melanesians.

The third upper molar tooth bears four cusps in only 37% (of all races): and in 6% of all Hominidae it is quite irregular in form.

Of the lower molar teeth, the first bears five cusps in 77% only, of highly-civilised races, but in Polynesians five cusps are the rule in 91% of examples. This is thus more variable than the first upper tooth.

The second molar tooth is very subject to variation; five cusps are found in only 33% to 37%, even in primitive races. Four cusps (and not five, as Zuckerkandl and Röse state) are apparently the normal number for this tooth.

The third molar tooth is also variable; four cusps are rare, and three are found in as much as 64% of highly-civilised races. Three cusps may thus be considered the normal number in these races. Even in the primitive races, such as the Melanesians, three cusps occur in 28% of cases.

On the whole, then, the upper teeth tend to become tricuspid, and the last tooth is degenerate to the verge of suppression. The lower teeth are in transition from a five-cusped pattern to a four-cusped type, the cusps being separated by a crucial fissure marking the dental crown.

There remains for notice a curious condition of the molar teeth most frequently observed in natives of the Chatham Islands (Mori-ori) and in Maories; also, but less commonly in Eskimo. The molar teeth are dislocated and inflected inwards, so that instead of the normal upper surface, the labial side of the crown comes into use: the significance and causation of the condition are quite obscure, but it would appear to be related to the nature of the diet of the natives among whom it obtains.

The Tongue. The tongue of the black races might be expected to prove larger, thicker, and less pointed than that of white men, in correspondence with the long hypsiloid palates found in the skulls of those races, but little or no information is as yet accessible on this point. A similar lacuna of observation exists with regard to the number and disposition of the circumvallate papillae. Humphry[1] describes these in a Chimpanzee as distributed along the median line of the tongue; but no comparative (human) observations are as yet accessible to the writer. With regard to the lingual musculature, Serres, quoted by Hovelacque and Hamy[2], states that the anterior fibres of the M. styloglossus are but feebly developed in negroes.

The Intestines. Chudzinski[3] discusses the relation of the length of the intestines to the stature in the white and black races respectively, and concludes that the proportion is less in the latter than in the former; for in negroes the intestine seems to measure from 4·14 to 6·11 times the amount of the stature, while in the white races the proportions cited by various authors vary from 3—8[4]. If the intestinal length be compared, not with the stature, but with the length of the vertebral column, the proportion

[1] *Journ. of A. and P.* Vol. v. Old Series.

[2] *Précis d'Anthr.* p. 301.

[3] *Revue d'Anthr.* 1887, p. 276. Chudzinski's records contain references to the proportionate length of the intestine in an Annamese, a Peruvian, and an Arab.

[4] The lower figure (3) is quoted by one anatomist (Cruveilhier) only.

in the negroes observed by Chudzinski agrees with that recorded in an Orang-utan by the same observer (about 10·28). But no records of this proportion are provided for the white races.

A comparison of the lengths of the small and large intestine respectively, indicates that the relative shortness of the intestine in negroes as compared with white men, is determined by the shortness of the small intestine, for the colon would appear to be absolutely and relatively longer in the black races. It may be noted that Chudzinski's series is quite a small one (of nine individuals).

Turner[1] records a double rectal mesentery in a male negro.

Flower and Murie[2] state that in a young Bush-woman the small intestine measured 15 ft., the large intestine 4 ft. (2·6 to 1), a proportion which is ultra-negroid and distinctly simian.

In the post-mortem room of the Greenwich Seamen's Hospital I saw the caecum of a mulatto; no unusual abnormality was present: the vermiform appendix was of moderate length and projected into the pelvic cavity.

Huntington[3] figures (*op. cit.* Nos. 519, 522, 526) three caeca of Eskimo natives of Smith's Sound. One of these (*op. cit.* Fig. 522) is described as similar in conformation to the caecum of a Gorilla (*op. cit.* Fig. 457) represented in the same work. The similarity is particularly noticeable in the position and form of the vermiform appendix. But the other Eskimo caeca do not present the same conformation, and the caecum of the Gorilla referred to, differs from that described in an earlier Chapter (IV.) of the present work. Here, again, the necessity for a statistical enquiry bearing upon both Simiidae and Hominidae is apparent.

The Liver. Chudzinski[4] states that in his series of negroes the average size and weight of the liver was less than the average in white men. At Cambridge two livers of negroes are available for observation. In one of these no important departure from the normal type of liver in the white races could be observed: and in particular no exceptional fissures suggesting division of the right or left lobes were noticed. The second liver would be considered

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[1] *Journ. A. and P.* XXXI. p. 624.   [2] *Journ. A. and P.* Vol. I.

[3] *The Anatomy of the Human Peritoneum and Abdominal Cavity.*

[4] *Revue d'A. loc. cit.*

quite anomalous in a white man. The most striking feature is the extension and large size of the left lobe. But where statistics are so scanty no stress can be laid on this record. The liver of the Annamese recorded by Chudzinski is smaller than that of the average white man. In the Bush-woman dissected by Flower[1], the liver weighed 54·75 oz. and measured 10×7 in. (about 250×175 mm., which is distinctly small). The lobar divisions corresponded to those usually described, and the caudate lobe, though rudimentary, was distinguishable (a simian feature), though not unusually extensive. The gall-bladder was small and cylindrical (i.e. infantile).

The Spleen. Chudzinski[2] states that while the volume of the spleen was on the average less in his negro series than in the white races, yet no appreciable difference existed in point of weight. In the Bush-woman dissected by Flower the spleen was pointed at either extremity.

A very generalized type of human liver is described and figured by Parsons[3]. The specimen is from the post-mortem room at St Thomas's Hospital.

The Pancreas. In the Bush-woman dissected by Flower no anomaly was observed in the pancreas.

The Larynx. The laryngeal sacculi of the larger Simiidae are not normally seen in the Hominidae, but among the latter a vestige of the former presence of saccules is said to be shewn in the larynx of the negro, inasmuch as the ventricles are here much more extensive and capacious than in the white man. In a negro dissected at Cambridge· the laryngeal ventricles were quite similar in this respect to those normal in the white races: it must not be overlooked, moreover, that in the latter, the laryngeal saccules of Simiidae are occasionally reproduced; to a case of this kind, recently met with (cf. Fig. 160) in the Anatomy School at Athens and reported in the *Anatomischer Anzeiger* (1902)[4], reference has already been made (cf. Fig. 220). In the Kroo negro dissected at Cambridge an accessory laryngeal muscle (cf. Fig. 221) was found. The same muscle has been observed by Mr Sewell in the larynges of human foetuses, in which it is conspicuous.

[1] *Journ. A. and P.* Vol. I.   [2] *Revue d'Anth. loc. cit.*
[3] *Proceedings of the Anatomical Society*, February, 1904.
[4] Cf. also Sclavunos, *Anat. Anz.* Band xxiv. Nos. 19 and 20.

With regard to the comparative morphology of the lungs within the Hominidae little or nothing seems to be known at present.

Saccule

Fig. 220.

Ep.

M.thy.ar. acc.

M.thy.ar. ext.

M.cr.ar. post.

M.cr.ar. lat.

Cr.cart.

M.sty.ph.

N.lar. rec.
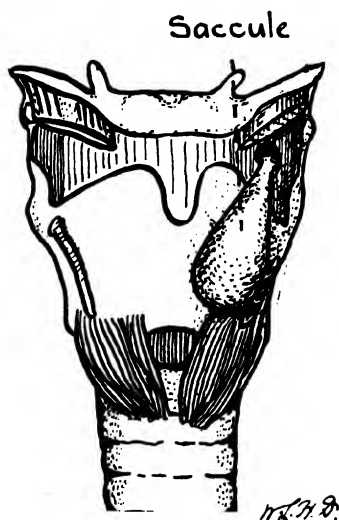
Fig. 221.

Fig. 220.   Laryngeal Saccules in Man.   (Cf. Fig. 160 and context.)
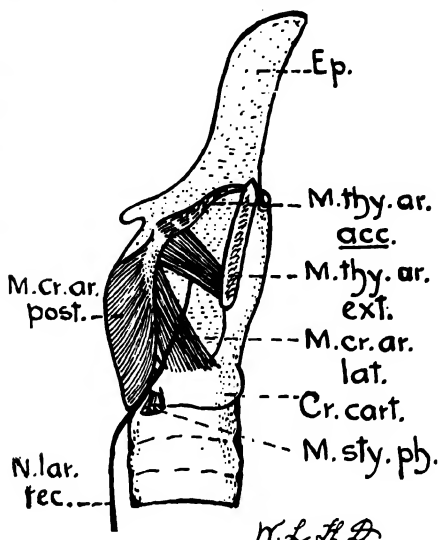
Fig. 221.   Larynx of a Kroo negro, dissected from the right side; there is an accessory muscle, viz. an accessory M. thyro-arytenoideus.   (M. thy. ar. *acc.*)

The Vascular System.   In the vascular system, the chief point of importance is the arrangement of the chief arterial trunks arising from the aortic arch.   The investigations of the Committee appointed by the Anatomical Society shew that the arrangements here diagrammatically represented are the commonest in white men, that of type (1) accounting for 88·2 of cases (cf. Fig. 222).   Keith[1] notes that the forms (2) and (3) are simian, and thrice as numerous in the black as in the white races.

1.   *2.*   *3.*
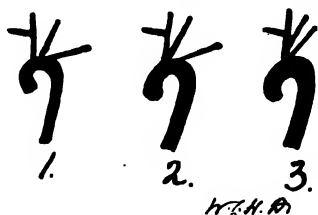
Fig. 222.   Diagrams illustrative of the three commonest modes (in order of frequency) of the origin of the great arterial trunks from the aorta in Europeans.

[1] *Journ. A. and P.* xxix. p. 458; also Parsons, *ibid.* xxxv. p. 389.

A negro (No. 3) dissected by Turner[1] presented the unusual (white) anomaly of a right subclavian artery arising alone from the descending aorta, below the ductus arteriosus; this represents a remnant of the right aortic arch (cf. Fig. 223).
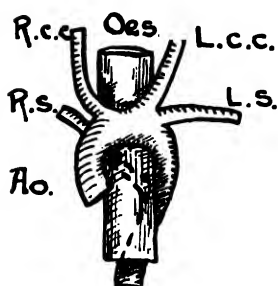
Fig. 223.
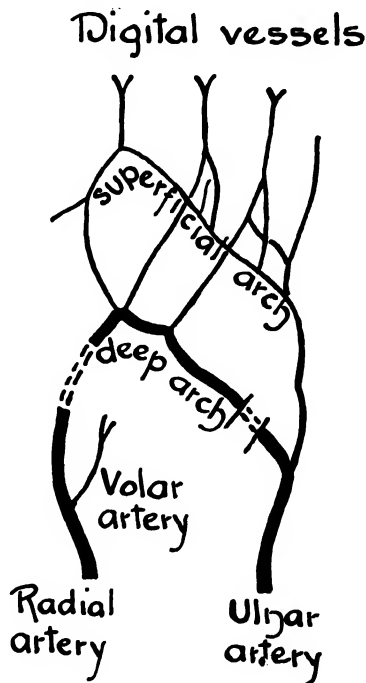
Fig. 224.

Fig. 223. Anomalous origin of the right subclavian artery (R.s.) in a negro.

Fig. 224. Palmar arteries (superficial and deep arches) in the left hand of a Kroo negro dissected at Cambridge (W.L.H.D.).

The above figure (224) represents the arrangement of the palmar arteries in a negro dissected at Cambridge. (No. 1. W.L.H.D.)

In the Bush-woman dissected by Flower the heart resembled the corresponding organ in white races. The aorta gave off three great trunks in the manner normal in white races, but the trunks were closely approximated. The vertebral arteries

arose from the subclavian arteries on each side. No "anomalies" were seen in the branches of either carotid or of the limb-vessels. At the base of the brain the left vertebral artery had a calibre double that of the right artery.

The Lymphatic system. Reduplication of the thoracic duct has been recorded in a negro[1].

The Genito-urinary system. The kidneys. Chudzinski's[2] records shew that in his negro series the volume and weight of the kidneys are on an average less than in the white races, while in both groups the left kidney is larger than the right. In the Bush-woman dissected by Flower no anomalies were seen in the kidneys.

The Suprarenal bodies. Chudzinski's[3] series of negroes shews that on the average the size of the suprarenal bodies is greater in the black than in the white races, but at the same time the weight is on the average much less in the former.

In the Bush-woman dissected by Flower no anomalies were seen in the suprarenal bodies.

Brown-Séquard and Pruner-Bey[4] state that both the suprarenal bodies and vesiculae seminales are larger in the black than in the white races: they agree herein, as regards the suprarenal bodies, with Chudzinski, but more observations are desirable before a final conclusion can be arrived at. Similar comment applies to the statement made by Hovelacque and Hamy[5] that the bladder is placed at a higher level in the black than in the white races: if so, this is an example of the persistence of an infantile character in the negro races; it is thus intelligible in view of the other infantile traits of the black races.

It remains to consider the external genitalia in the two sexes.

A. *The Male.* The relatively greater size of the penis in negroes has long been recognised. The os penis is unknown in Man.

[1] Turner, *Journ. A. and P.* xiv. p. 244.
[2] *Revue d'A. loc. cit.*   [3] *Revue d'A. loc. cit.*
[4] *Bull. de la Soc. d'Anth. de Paris*, 1860, p. 30.
[5] *Précis d'A.* p. 302.

B. *The Female.* Turning to the external genitalia of women, the relatively feeble development of the mons veneris and labia majora in negro races and in Bush-women has been claimed, with some justice, as a simian characteristic. The labia minora are variable in their development in the black races, for in some instances they would seem to be relatively smaller than in white women: in the black Hamitic tribes of Abyssinia the labia minora are said to be relatively large. The extreme of this hypertrophy is attained in the Bush natives, and the following notes give an account of the conformation of the generative organs of a Bush native (young woman)[1].

The external genitalia presented the very striking and characteristic conformation of the females of this race, viz. the small labia majora vulvae associated with elongated pendulous labia minora; the latter in this young woman were of triangular form, the base extending anteriorly into a larger prominent prepuce which covered a clitoris of moderate dimensions. The labia minora thus differ from those described in the same paper (q. v.) in older women as drawn out into a thong-like form with expanded extremity.

These characters of the genitalia are not simian, and consist in an excessive development of the condition normal in the female foetus of white races, and in women of black races. The clitoris is said to be relatively larger in certain black races, and would thus suggest a resemblance with some of the lower primates, especially certain of the Lemuroidea, in which the clitoris is greatly developed. The vagina in the black races is said to be longer than in women of white races.

Muscular system. Materials for the study of the comparative muscular morphology of the human races are even at the present time very scanty, although the observations are daily increasing in number and accessibility. Moreover at the present time no general summary is accessible, comparing or bringing into line the results recorded by various observers. The remarks on this section must therefore needs be limited, not because the subject is unimportant, but because no final account can yet be submitted.

[1] Flower and Murie, *Journ. A. and P.* Vol. i. Also Blanchard, *Bull. Soc. Zool. France*, 1883.

For the sake of convenience we shall consider the muscular system under the two headings of "A, Muscles of Expression and their allies"; "B, The general Skeletal Musculature."

A. *Muscles of Expression and Associated Muscles.* The comparative study of the muscles of expression has received more attention than has been devoted to any other group of muscles[1]. Nearly a century ago Sir Charles Bell wrote a work which has become classical, on the expression of the emotions and its anatomical basis, dealing with the anatomy of the facial muscles of expression and with their nerve-supply.

Following this work came those of Darwin (*The Expression of the Emotions in Man and Animals*), and Duchenne de Boulogne; the former dealing with the subject from the standpoint of evolution, the latter taking up the relation of the nerve-supply and superficial landmarks, as well as the pathological conditions of these structures (e.g. facial paralysis).

Of late years numerous dissections have been made of the muscles of expression in the Simiidae, and in various racial types of the Hominidae. In the case of the Simiidae, the classical work of Duvernoy on the muscular anatomy of the Gorilla[2] is to be noticed, as well as more recent publications by Deniker[3] and Ruge[4].

Dissections of the facial muscles among the Hominidae and in the black races have been described by Hartmann[5], Popowsky[6], Turner and other writers in the *Journal of Anatomy and Physiology*[7], so that on this subject a considerable amount of information is now available. But in none of these cases is much more than a mere record provided.

The work of Broca's demonstrator, Théophile Chudzinski, published in 1896, supplies a great want in this respect, for in it are recorded the results of dissections on several negroes, several examples of the yellow race, with one or two white men for

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[1] Camper's work, 1789, deals principally with the physiology rather than the anatomy of the muscles of expression.

[2] *Nouvelles Archives du Muséum*, Vol. x.   [3] *Thèse de Paris*, 1885.

[4] *Gesichts-muskeln der Primaten.* Also *Morphologisches Jahrbuch, passim.*

[5] Hartmann, *Anthropoid Apes.* International Scientific Series.

[6] Popowsky, *L'Anthropologie*, 1890 (also quoted by Chudzinski).

[7] See especially Vols. xiii. xiv. xxxi.

comparative purposes. From this remarkable monograph we obtain evidence of a comparative kind not otherwise so concisely or exhaustively provided. For this reason we shall now give an account of Chudzinski's results, in so far as they bear on the subject actually in hand.

Before entering upon this however, a few preliminary remarks on the general conformation of the system of cutaneous muscles as elucidated by the recent work of Parsons[1], seem appropriate in this place.

In a general review of Eutherian cutaneous musculature the following elements are most commonly recognisable: (a) M. platysma, (b) M. sphincter colli, (c) M. dorso-humeralis, (d) M. abdomino-humeralis.

(a)   The ordinary extent of the M. platysma needs no elaborate description in this place: in view of its nuchal distribution and extent in primitive forms, this sheet is appealed to as the origin of the muscles of the external ear.

(b)   The M. sphincter colli (cf. Figs. 36 and 225) lies in a plane deeper than that of the M. platysma: mesially and ventrally (anteriorly in erect animals) it converges to its fellow, ending in decussation, or downward prolongation to the sternum, or even the abdomen, occupying in (the rodent) Bathyergus a position analogous to that of the anomalous human M. sternalis, with which it is identified by Parsons. (The question is however still under discussion, and cases such as those reported by Eisler[2], shew that the M. pectoralis major may be the immediately derivative mass. It would seem that Cunningham concurs in this view, while Parsons has suggested that the pectoral mass may be a derivative of the panniculus system. The community of nerve-supply supports the latter view.)

The M. sphincter colli is absent from Cheiroptera (Bats), is very evident in Lemuroidea (cf. Fig. 36), but above these diminishes, till in Man only a few transverse submental fibres remain. It is noteworthy that in the extensive researches undertaken by Chudzinski, distinct traces of the submental transverse fibres

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[1] "The Panniculus carnosus and its representatives," *J. A. and P.* Vol. XXXIII. 1898.

[2] *Zeitschrift für Morphologie und Anthropologie*, Band III. Heft I. 1901.

were rare. Transverse fibres (muscular) certainly occurred, especially in a negro (from Pondichéry), but these lay *superficially* to the platysma sheet, and hence could not be claimed as remnants of the M. sphincter colli which *underlies* that sheet. In animals (like Bathyergus) in which it is well-developed, it obtains its nerve-supply from the internal anterior thoracic nerve, i.e. from the inner cord of the brachial plexus.

(c) The M. dorso-humeralis winds round the tendon of the M. latissimus dorsi to reach the humerus, passing deeply to the M. pectorales: it is very prominent in Cercopithecidae and lower primate forms, including the Lemuroidea; in Man an anomalous muscular slip, known by its German name of "Achsel-bogen," is claimed as a remnant of this dorso-humeral muscular stratum. (The "Achsel-bogen" is said to be innervated from the inner cord of the brachial plexus.)

(d) The abdomino-humeralis sheet is probably lost in the sheath of the M. rectus abdominis: in rodents this sheath splits to enclose the M. pectoralis major, on reaching the lower border of that muscle[1].

The accompanying diagram (Fig. 225) provides a plan of the distribution of these various elements.

Fig. 225. Cutaneous musculature of a Raccoon, to shew the several constituents; (a) M. platysma, (b) M. sphincter colli, (c) M. dorso-humeralis, (d) M. abdomino-humeralis (after Parsons).

When we turn to researches carried out on the Simiidae and Hominidae we find the several elements just enumerated in

[1] This muscular stratum is represented in the perinaeal region. Lack of space precludes further description of its representatives, but reference should be made to researches by Kollmann and Thompson; and especially to memoirs published by Lartschneider (*Sitz. der K. Akad. d. Wiss in Wien. Math.-Nat. Kl.* 1895, Band. crv. pp. 150—190), and Holl. (*Anat. Hefte*, 1901).

a vestigial condition, less vestigial however in the Simiidae than in the Hominidae; moreover the platysma layer is the most persistent of the four; and apparently it may become segmented into several superimposed strata. Chudzinski's researches on the several human races led to general statements, of which a *résumé* is now appended[1].

Several layers of cutaneous muscles undoubtedly exist, and in the "black" races the distinction between muscles is much less clear than in the white races, the yellow races standing in an intermediate position in this respect. (Chudzinski's "yellow races" must be taken to refer to Chinese and Indo-Chinese: no true Mongols were examined: the conditions in American Indians and a Cingalese resembled those of white races.) The muscles of the face in the black race are also distinguished by throwing out off-shoots which run into and blend with adjacent muscular elements. In the black races, too, the muscles of expression are more distinctly red than in the white races.

Further general remarks apply to particular muscles, and of these a selection will now be given:

M. frontalis: sex seems to have no value as a factor in determining variations here: the condition in a New Caledonian (Oceanic negro) recalls that in the Gorilla.

M. pyramidalis: the blending of this muscle with the M. frontalis in a Zulu woman recalls the condition in the Gorilla. (Cf. Chudzinski; *Bull. de la Soc. d'A. de Paris*, 1886.)

M. auriculares: these, and indeed the auricle itself, are diminished *pari passu* with the augmentation of the clavicle and associated freedom of the anterior limb (Chudzinski).

M. auricularis posterior (retrahens auris): most variable in the black races.

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[1] Chudzinski's material included,

Black races:	8 male Negroes.
	4 Negresses (2 Egyptian, 1 Zulu).
	1 male New Caledonian.
	1 Negro, native of Pondichéry.
Yellow races:	2 Annamese.
	2 Cochin-Chinese.
	1 Peruvian.
White races:	1 Arab.

M. auricularis anterior (attrahens auris) is most distinct in the black races.

M. occipito-parotideus and M. mastoideo-parotideus occur (anomalously) most frequently in the black races.

M. orbicularis palpebrarum in the black races is thick and composed of interlacing fibres; it throws out radiating offshoots into adjacent muscles, such as the M. zygomaticus major, and the M. levator labii superioris, and also into the skin of the cheek[1]. This is seen in the case of the aboriginal (male) native of Australia (Mus. Anat. Cant. cf. Fig. 226).

M. zygomaticus major: most variable in the black races, and often closely associated with the M. risorius. It is often connected with the M. orbicularis palpebrarum, as is also noted by Turner (*J. A. and P.* Vol. XIII.), and as is seen in the dissection of the head of an aboriginal native of Australia in the Cambridge Museum of Anatomy. (Cf. Fig. 226.)

M. platysma in black and yellow races extends higher than in the white races (as far as the zygoma; Turner): its nuchal portion often appears detached as a M. transversus nuchae (see also Turner, *op. cit.*). The great upward extent is seen in the head of the aboriginal of Australia in the Cambridge Museum of Anatomy.

M. rectus sternalis has been observed in a negro by Turner.

The remainder of Chudzinski's conclusions are best studied in tabular form[2], whence it clearly appears that the muscles of the cutaneous system are more extensive in both black and yellow than in white races, the order being black, yellow, white. In one

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[1] This condition is particularly remarked as occurring in a Papuan infant, cf. Forster, *v. infra* p. 385.

[2] A general survey of tabulated results shews that in respect of twenty-one characters relative to the extent of the muscular sheet in the several races the order runs:

Black, yellow, white, in 13 instances.
Black, white, yellow, in 1 instance.
Yellow, black, white, in 3 instances.
Yellow, white, black, in 3   ,,
White, yellow, black, in 1 instance.
White, black, yellow, in 0   ,,
                                   ————
                               21 instances.

sense however, the segregation (in the white races) of these muscles is not altogether a matter of degeneration, for at least it can be claimed that it is associated with a greater degree of individual muscular specialization.

Fig. 226.   Dissection of the facial musculature of an aboriginal native of S. Australia (Mus. Anat. Cant.).

B. *The Skeletal Musculature proper.* From the cutaneous group of muscles we now pass to the skeletal group. In this connection again the chief contributions have been made by Chudzinski (*Mém. de la Soc. d'A. de Paris*, 1898). The detailed discussion of the results collected from the several records would be here impossible, and moreover it belongs rather to the section dealing with anatomical anomalies in general, for it is to these that the attention of observers has hitherto been chiefly directed. Such being the case, it is here proposed to submit the briefest notices of some of the accessible accounts of such dissections as

have been made on the bodies of representatives of other races than the white.

As a general statement, it may be remarked that in the more prognathous " heavy-jawed " individuals, of whatever race, the mass of the mandibular (temporal, masseteric, and pterygoid) muscles is correspondingly increased.

The ensuing notes deal with the muscular anatomy of several individuals of the black and yellow races, the records being drawn from the following sources :

    I.   A Papuan infant (Forster, *Anat. Anz.* XXIV. No. 7, p. 183).

    II.   A Kroo negro (Mus. Anat. Cant. W.L.H.D.).

    III.   Four negroes and a native of Dacca (Turner and Bryce, *Journ. A. and P.* Vols. XIII. XIV. and XXXI.).

    IV.   A Chinaman (Anderson Stuart, *Journ. A. and P.* Vol. XIX.).

    V.   A Bush-woman (Flower and Murie, *Journ. A. and P.* Vol. I.).

Chudzinski has published an exhaustive memoir on the myology of several negroes, and other individuals of exotic provenance (such as a Peruvian and an Indo-Chinaman) dissected by him (*Mém. de la Soc. d'Anth. de Paris,* 1898) ; and Giacomini has also contributed to the subject of negro myology.

I. *Papuan.* Forster dissected a newly-born Papuan infant, which is in the Anatomical Museum at Strassburg. He notes that though instances of muscular variations of a "progressive" character were detected, yet they were overshadowed in number by variations of the "reversionary" order. As "progressive" variations the following examples are cited : (*a*) complete independence of the M. adductor minimus : (*b*) the tendency to isolation of that part of the M. flexor profundus digitorum which supplies the index finger : (*c*) the complete differentiation of the thenar and hypothenar musculature of the hand, and the corresponding elements in the foot. As "reversionary" in their significance, the following anomalies (amongst others) are remarked : (*a*) the lack of differentiation and the thickness of the facial muscles of expression (*v. supra,* p. 382) : (*b*) accessory serrations of the M. serratus anticus (magnus) : (*c*) unusual extent of the M. pronator quadratus : (*d*) presence of a M. gluteus quartus : (*e*) the M. psoas minor was present, and herein Chudzinski's results are modified, for that observer had not been able to record the presence of the M. psoas minor in the coloured races : (*f*) the M. plantaris was quite rudimentary ; Chudzinski stated that this muscle is very constant in the coloured races.

II. *Negro.* A Kroo native.

    1. M. subscapularis : the humeral attachment is more extensive than in Europeans, and is overlapped by the tendon of his M. latissimus dorsi.

    2. M. latissimus dorsi : a scapular component is present : no M. latissimo-condyloideus is present.

3. M. coracho-brachialis : not subdivided as in the Simiidae.

4. M. biceps cubiti : there are no accessory heads of origin.

5. M. brachialis anticus : that part which lies externally to the insertion of the M. deltoideus is very bulky. Inferiorly this muscle is inseparable from the M. triceps.

6. M. extensor ossis metacarpi pollicis : this muscle sends a tendon to the M. abductor pollicis.

7. M. extensor primi internodii pollicis. The tendon splits into two parts, of which one runs to the proximal phalanx of the pollex, the other joining the tendon of the distal extensor of the thumb. The muscle arises from the interosseous membrane as well as from the radius.

8. The M. deltoideus, supraspinatus, infraspinatus, teres minor, anconeus, extensores (of the wrist and digits) subscapularis, supinatores, palmaris longus, flexores and pronatores agree with the descriptions of the corresponding muscles in the white races.

15. In the larynx, an accessory thyro-arytenoid muscle was found. (Cf. p. 374, and Fig. 221.)

III. The dissections of negroes published by Turner are three in number.

In No. 1 the following are striking features, *J. A. and P.* Vol. XIII. p. 382 :

1. The M. platysma extends up to the zygoma and a M. transversus nuchae is present.

2. The M. omohyoideus arises from the clavicle and not the scapula.

3. The M. constrictor pharyngis superior receives fibres from the M. tensor palate.

4. The M. pect. minor sends an expansion from its tendon of insertion over the shoulder-joint capsule.

5. The M. brachialis anticus is bilaminar.

6. The M. pectineus supplies a slip of muscle from its inner border to the tendon of the M. adductor longus.

7. There is present a M. accessorius ad M. flexorem accessorium.

8. The M. peroneus is attached to the os calcis.

9. The M. lumbricalis quartus is absent.

10. The M. plantaris arises by two heads.

Negro 2 (Turner, *J. A. and P.* Vol. XIV. p. 244).

1. The M. zygomaticus major is blended on one side of the face with the M. orb. palpebrarum.

2. The M. biceps cubiti has two accessory humeral heads.

3. The M. flexores digitorum sublimis and profundus are connected by a tendon.

4. The (right) M. plantaris has no muscular elements; it arises as two tendons.

5. The (right) M. flexor longus hallucis sends slips to the second and third digits (toes).

6.   No M. peroneus tertius is found, but a slip to the right metatarsal is provided by the M. ext. digitorum longus.

7.   The (right) M. abductor ossis metatarsi quinti is present.

Negro 3 (Turner, *J. A. and P.* Vol. XXXI. p. 624).

1.   The M. platysma is well developed and a M. rectus thoracis (? M. sternalis) is present.

2.   The M. flexor digitorum sublimis has no radial head (according to Keith, the *ulnar* origin is rare in Gorilla), and its tendon to the index finger has a fleshy belly interposed at the level of the lower third of the radius.

3.   The M. semitendinosus has accessory slips.

4.   The M. peroneus tertius is absent. (This muscle was absent in Negro No. 2 also, and such absence is distinctly a simian characteristic.)

5.   The M. gastrocnemius has an additional muscular origin for its inner head.

6.   The M. flexor brevis digitorum provides no tendon to the fifth toe.

7.   The M. abductor ossis metatarsi quinti is present in both feet (this is rare in Gorilla).

Negro 4 (Bryce, *J. A. and P.* Vol. XXX. p. 611).

1.   The M. adductor magnus shews fasciculation unusually distinctly.

2.   The M. biceps femoris has an accessory fasciculus.

3.   There were 34 anomalies recorded altogether : it was remarked that in the upper limb they tend to be unilateral, but bilateral in the lower limb.

Native of Dacca in Bengal (Turner, *J. A. and P.*). The following conditions were noted.

1.   The M. sterno-mastoideus is tripartite.

2.   The M. scalenus anticus originates by one slip less than in white men.

3.   The M. transversalis colli arises from the transverse processes of the upper ten thoracic vertebrae.

4.   The M. latissimus dorsi arises from the *four* lower ribs.

5.   The M. serratus magnus is attached to ten ribs on one side (R.), nine on the other side.

6.   The M. pectoralis major sends a slip to the common (coracoid) tendon of the short head of the M. biceps and the M. coraco-brachialis.

7.   The M. subclavius is absent on the left side.

8.   The M. palmaris longus is absent on one side (the right).

9.   The M. extensor carpi ulnaris has an accessory slip.

10.   The M. pronator quadratus is bilaminar.

11.   The M. extensor indicis has a muscular belly interpolated in its tendon.

12.   The M. lumbricalis quartus manus is rudimentary.

13.   The M. plantaris is absent from one side (the right), cf. No. 8.

14.   The M. flexor brevis digitorum provides three tendons only.

15.   The M. flexor accessorius is attached to the M. flexor longus hallucis, not to the M. flexor longus digitorum.

IV. *Chinese.* The following notes form an abstract of the account of the myology of a Chinaman: Stuart, *J. A. and P.* Vol. XIX.

The abnormalities in the muscular system may be generally described as tending towards the exuberance or redundancy of muscular tissue.

Thus the M. rect. cap. majores are large, completely covering the M. rect. cap. minores.

The M. rect. cap. minores consist of three separate slips.

The posterior belly of the M. omohyoideus is replaced by a membranous tendon.

A communicating slip of muscular tissue replaces the tendon of the M. digastricus.

The M. scaleni medii have accessory origins.

Several muscles in the upper extremity are provided with accessory tendons. Thus the M. abductor pollicis has two tendons.

The tendon of the M. supinator longus is bifid, transmitting the radial nerve.

Some of the M. lumbricales of the foot are absent : viz. in the right foot, No. 3 ; in the left, Nos. 2 and 3.

V. *Bush native.* The dissection of a Bush native (young woman) by Messrs Flower and Murie revealed the following disposition and characters of the muscular system.

The facial muscles of expression shewed no striking peculiarity, and except that there was a slightly greater tendency than in the white races, for the several muscles to merge into one another, and thus form sheets, no simian features were discovered.

The M. omohyoid had no posterior belly or tendinous intersection: the anterior belly was attached to the clavicle (but this anomaly is noted by the authors as occurring in about 3% of white individuals).

The M. cleido-occipitalis was present : this is distinctly a simian or lower Eutherian feature (the muscle common in Carnivora and known as the M. cephalo-humeralis, is allied to this muscle, of which it is regarded as the perfect form). It occurs abnormally in the white races.

No trace of the M. latissimo-condyloideus (dorsi-epitrochlearis) was seen.

The M. rect. cap. posticus major was partially divided : in the Canidae it is normally double.

The M. coraco-brachialis was double.

The M. ext. pollicis minor was present and resembled its counterpart in the white races.

The M. add. pollicis transversus had accessory origins from the fourth metacarpal bone and (by a tendinous band) from the fifth metacarpal, but in compensation the area of attachment to the third metacarpal was diminished.

The M. gluteus maximus was thin, and it covered the M. gluteus medius less completely than in the white races This lack of extent is a simian feature.

The M. peroneus tertius was present.

The M. ext. brevis digitorum supplied tendons to the 1st and 4th digits only.

The M. flexor brevis digitorum presented simian peculiarities, for it was composed of two parts : the larger calcanean part supplying the three middle digits, the fifth toe being supplied by a muscular belly which, as is common in Simiidae and other Primates, took origin from the long flexor tendon.

The tendon of the M. flexor hallucis longus provided slips for the fourth, as well as the second and third digits.

The authors remark that the last two conditions constitute deviations from the type of the white races, as pronounced as any up to that time on record, but they clearly recognise that the occurrence of these anomalies in a single individual affords but little justification for a general statement affecting the race.

Peripheral nervous system and sympathetic nervous system. The observation made many years ago by Soemmering and Jacquart, to the effect that the nerves are larger in the negro than in the white man, does not appear to have been confirmed by later writers.

The following observations are available in connection with this part of our subject.

In a negro Turner observed (*J. A. and P.* Vol. XIV. p. 244) a large gangliform enlargement on the left splanchnic nerve.

In the same negro, the lesser occipital nerve was represented by two distinct nerves; and the ulnar nerve was formed by the union of heads of origin from inner and outer cords respectively of the brachial plexus (Wood, *Proc. Roy. Soc.*, June 15, 1865, records a similar condition in a negro). In another negro, Turner (*J. A. and P.* Vol. XXXI. p. 624) records an additional origin of the phrenic nerve from the fifth cervical nerve : in the same negro the gluteal and sciatic nerves were abnormal, and the cutaneous branches of the obturator nerve pierced the muscle of that name.

With regard to the nerves of the lower limb the following observations are available. From a large number (17) of dissections, Bardeen and Elting[1] obtained results which shew that in the negro races the type of lumbo-sacral plexus, known as the

[1] *Anatomischer Anzeiger*, Band XIX. s. 217.

"posterior" type, is more prevalent than in the white races. This statement holds good for both sexes alike. At the same time the number of segments contributing nerves to this plexus seems to be about equal in the black and white Hominidae alike.

In the dissection of the Bush-woman, to which reference has already been made[1], Flower and Murie found that the peripheral nerves of the lower limb presented no anomalies of distribution, as judged by the standard of the white races.

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[1] *Journ. A. and P.* Vol. i.

CHAPTER XV.

THE COMPARATIVE MORPHOLOGY OF THE CENTRAL NERVOUS SYSTEM.

THE study of the comparative morphology of the central nervous system in general, and of the cerebrum in particular, is fraught with unusual interest in view of the association of psychological phenomena with this system. It may indeed be said (notwithstanding the warning uttered in the earlier part of this book as to the inexpediency of selecting as criteria of comparison a single character, or the characters drawn from a single morphological system) that the study of the brain, viewed from this standpoint, constitutes an epitome of the whole study of human morphology. For just as any one of the higher animals may be regarded as a complex of morphological systems, so the encephalon consists of a number of component parts; and just as the existing mammals differ morphologically as the result of specialisation having proceeded to different lengths in the various systems, so when observation is restricted to the encephalon, differences are seen to obtain among the members of various sub-classes, orders, and families of mammals, according to variations in the extent of modification to which the several components of this particular part of the nervous system have been subject. Exactly, too, as the evidence of morphological conformation, taken as a whole, is perfectly explicit as to the position of the Hominidae in the Eutherian series, so also the evidence of this particular group of tissues does not falsify the anticipations that will have been formed from the examination of the skeletal, the muscular, or other systems.

It is but natural, therefore, that a plan of campaign similar to that of which an exposition has been attempted in the preceding

Chapters should be pursued. And therefore it is that the headings under which the central nervous system will be considered are, (a) the Encephalon, (b) the Spinal Cord; and the characters of each of these components will be briefly reviewed in relation to (1) comparative morphology, (2) embryology, (3) variations, and (4) palaeontology.

I. **Comparative morphology.** As might be expected in view of the extraordinary manifestations of the Hominidae, the human encephalon presents an example of remarkable specialisation when compared with those of all other animals. The particular part of the encephalon thus modified in Man is that to which the name Neopallium is applied, and our first enquiry must be made into the relations of the neopallium to the other components of the encephalon. Morphologically, the neopallium is derived from that portion of the tube by which the central nervous system is primitively constituted, which occupies its anterior extremity; it forms part of the Telencephalon, the position of which is represented in the accompanying diagram of these structures as they appear in human embryos of about four weeks. (Cf. Figs. 227 and 228.)

The Telencephalon as thus defined, gives rise to various structures: ventrally, the cerebral component of the hypophysis cerebri is derived from it; laterally, a vesicle projects, the rudiment of the cerebral vesicle, the lower wall of which was observed by Reichert to become thickened, while its upper wall remained (for a period) comparatively thin. The thickened lower part (which gives rise among other structures to the corpus striatum)[1] was termed by Reichert "Stammlappen," in contrast to the thinner upper portion, which was termed "Pallium."

To these terms a third, viz. Rhinencephalon, was subsequently added, but extended research especially on the side of comparative anatomy, shewed that under both stammlappen and pallium was included a heterogeneous assembly of structures, some of which at least should, in accordance with the indications of morphology, be added to the structures grouped under the third term, Rhinencephalon. Moreover, as employed by various writers the limits

[1] Cf. Elliott Smith, *J. A. and P.* 1901, p. 435, *et seq.*

of the several structures were but loosely defined, and confusion was at its height when in 1901 Elliott Smith came to the rescue with a series of proposals for the clear definition, upon morphological grounds, of the significance and limits of the descriptive terms to be employed. Elliott Smith recognises in Mammalia the following components of the fully developed wall of the cerebral vesicle.
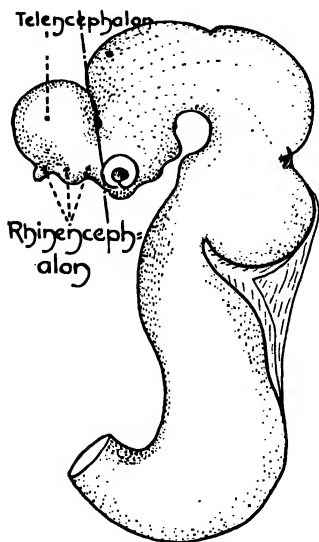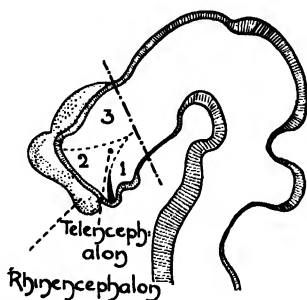
Fig. 227.   Fig. 228.

Fig. 227 (after Kollmann). The human encephalon at about the twentieth day of foetal existence. The Telencephalon is that portion of the primitive neural tube which is represented anteriorly to the interrupted line.

Fig. 228 (after His). The human encephalon at a stage corresponding to that represented in Fig. 227. The nervous tube is here represented in section. As in Fig. 227, the Telencephalon is that part which is situated anteriorly to the interrupted line. For the full terminology of the divisions of the Encephalon in this early stage, *v*. Barker, *The Nervous System*, p. 160; or van Gehuchten, *Anatomie des Centres Nerveux*, p. 17.

(a) *The basal pallium or pyriform lobe*: the limits of which are thus defined. (Elliott Smith, *J. A. and P*. Vol. XXXV. p. 433.)

"The anterior portion is closely applied, and attached to the lateral aspect of the corpus striatum (Fig. 233), and extends forward so as to pass into direct continuity with the olfactory

peduncle, its peculiar (histological) structure undergoing a gradual transition into the somewhat indefinite 'peduncular' formation; its antero-ventral part is covered by the thick mass of the tractus olfactorius (lateralis) (Fig. 229, 4'), radiating fibres of which are spread over the whole of the pyriform lobe. In its caudal part the pyriform lobe becomes free from the corpus striatum, and becomes a real 'mantle' (Fig. 233) which extends in the caudo-mesial direction to become continuous with the hippocampus."

(b) *The marginal pallium* (cf. Elliott Smith, *Cat. Roy. Coll. Surg. Mus.*, Physiol. Series, Vol. II. p. 142, *et passim*; also *J. A. and P.* Vol. XXXV. p. 499), or hippocampal formation, includes "not only the hippocampus (sensu stricto) but also the
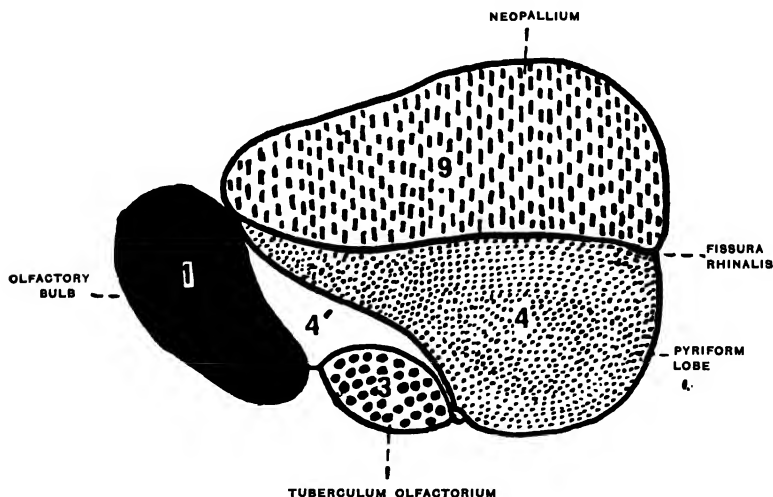
Fig. 229. Scheme of the mammalian cerebrum with the several components indicated. Left lateral aspect.

In this, and the four following diagrams (kindly lent by Professor Elliott Smith), indications are provided as follows, by means of numerals.

(1) The olfactory bulb.
(2) The olfactory peduncle.
(3) The olfactory tubercle (tuberculum olfactorium).
(4) The pyriform lobe. (4'). The lateral olfactory tract.
(5) The "paraterminal body."
(6) The anterior perforated space.
(7) The hippocampal formation, sharply differentiated into (a) the hippocampus, sensu stricto, and (b) the fascia dentata.
(8) The corpus striatum.
(9) The rest of the hemisphere, consisting of a dorsal cap, which is the neopallium.

fascia dentata, the hippocampus nudus (Zuckerkandl's *Balken-windung*), the supra- and pre-callosal vestiges of the hippocampus, and the fornix (fimbria). (Figs. 231, 232.)
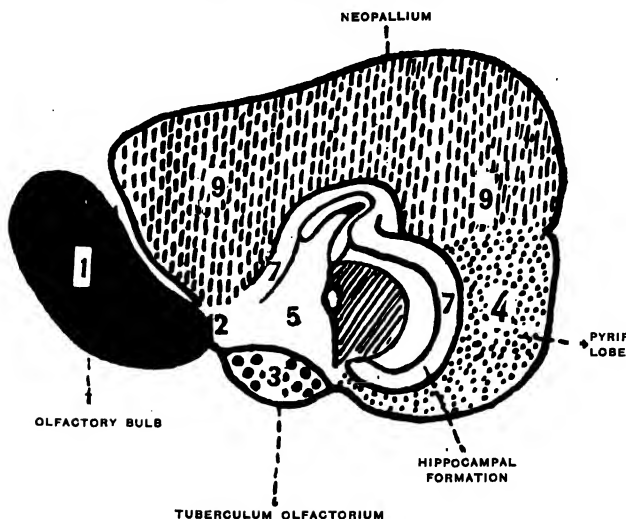
Fig. 230. Scheme of the mammalian cerebrum, with the several components indicated. Mesial aspect. For references *v*. Fig. 229.
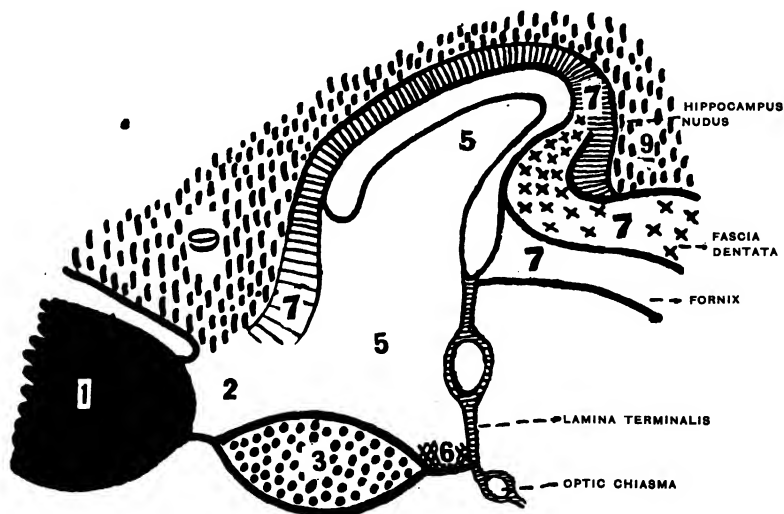
Fig. 231. The central portion of Fig. 230 on a larger scale. For references *v*. Fig. 229.
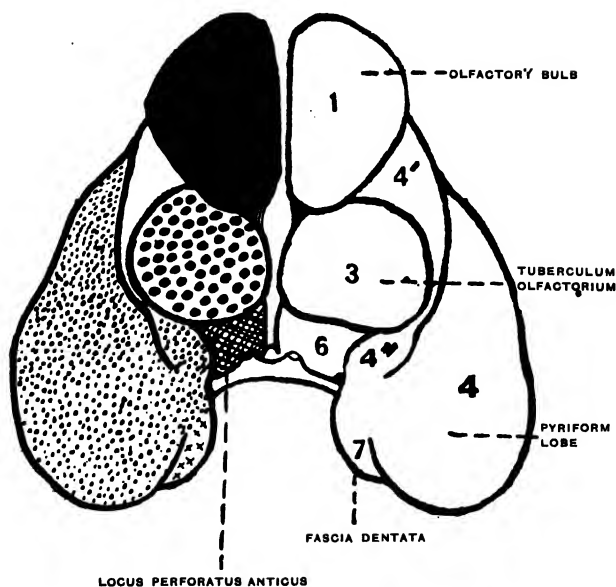
Fig. 232. Scheme of the mammalian cerebrum with the several components indicated. Ventral aspect. For references *v*, Fig. 229.
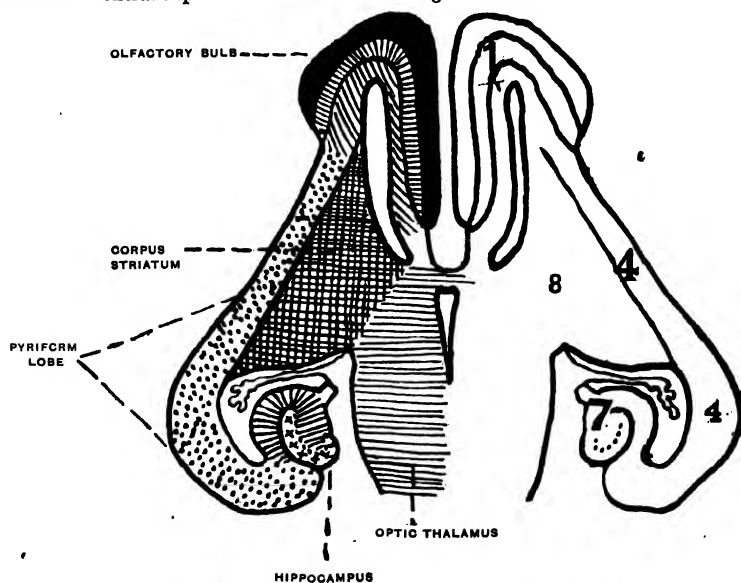
Fig. 233. Schematic section in a horizontal plane through the mammalian cerebrum. For references *v.* Fig. 229.

For Elliott Smith the rhinencephalon includes both (*a*) and (*b*), the basipallium and marginal pallium, together with the following structures (cf. Figs. 229—233, inclusive):

> the olfactory bulb,
> the olfactory peduncle,
> the tuberculum olfactorium,
> the locus perforatus anticus,
> the paraterminal body.

When 'the foregoing structures, together with the corpus striatum and such portions of the wall as remain in a permanently membranous or epithelial condition (covering the choroid plexuses of the lateral ventricles) are eliminated, there still remains a residue of the cerebral vesicle unaccounted for. This is what Elliott Smith recognises as

(*c*) *The dorsal pallium, or neopallium.* "A morphologically well-defined cortical area, which is the most important feature of the whole brain, or for that matter, of the whole body in the higher Eutheria; that part of the cerebral hemisphere which is responsible for the greatness of the mammalian brain, and overshadows in its greatness and usurps many of the functions of all the other regions of the nervous system, that great progressive cortical field, the high development of which becomes in the Mammalia the great fundamental condition of their survival; a great unlimited area (far removed from the disturbing influences of the purely 'administrative' parts of the nervous system), where 'impulses of diverse nature' coming from all regions of the body, and from all the sense organs, may 'meet and play upon each other'."

Such then is the definition and such the status of the neopallium in the Mammalian encephalon. In the Reptilian encephalon, the basipallium, the marginal pallium, the remaining constituents of the rhinencephalon, and the corpus striatum, account for practically the whole of the (non-epithelial) cerebral vesicle: yet even in the brain of the reptile (e.g. Hatteria), a rudiment of the dorsipallium (neopallium) is recognisable; and from the Reptilia upwards, the importance of the neopallium increases progressively, with concomitant reduction of the rhinencephalon, till a climax

is reached in the brains of the Hominidae. Before passing on, two more remarks must be added to this somewhat lengthy but most essential preface; in the first place, the several structures here enumerated, have been differentiated largely by the aid of histological methods, which have here been applied with the result of demonstrating peculiarities characteristic of each. Secondly, to each of these three divisions of the pallium is attached a special commissural system, the basipallium and marginal pallium sharing the larger part of the ventral commissure (anterior commissure of human anatomy), and of the primitive dorsal commissure now recognisable only in the psalterium of the fornix; while the neopallium of one hemisphere is connected with its fellow of the opposite side by means of a commissure developed later in the evolutionary history of the Mammalia than either of the foregoing, and known as the corpus callosum[1]. The size of the corpus callosum bears a direct relation to the mass of the neopallium, and in such Mammals as possess the most highly developed neopallium, the corpus callosum has attained its maximum development in point of size, overshadowing the more archaic ventral and dorsal (psalterium) commissures; to gain a proper appreciation of the latter, the brains of the more lowly Mammals or of Reptiles, wherein the corpus callosum has not yet been evolved[2], must be examined. (Cf. Figs. 234 and 235.)

[1] This statement requires some qualification. Although the corpus callosum, the psalterium (dorsal commissure), and the ventral (anterior) commissure are recognisable as distinct entities in the brains of the higher Eutheria, yet it appears from the researches of Elliott Smith (cf. *Linnean Transactions*, 1900, Vol. VIII. p. 47) that the commissure fibres of the neopallium when first they appear in the vertebrate series, i.e. in Reptiles (cf. brain of Hatteria), cross in the latter, viz. the ventral commissure, the dorsal commissure being retained for hippocampal fibres. But with the increase in the number of neopallial fibres, the ventral commissure becomes inadequate to the task imposed upon it, and the neopallial fibres, forsaking it, betake themselves to the dorsal commissure, of which they thenceforth constitute a separate and entirely distinct section, viz. the corpus callosum. Elliott Smith has most admirably demonstrated the series of Mammalian brains in which this evolution may be phylogenetically traced, and points out that the phylogenetic history is confirmed by the evidence of ontogeny as provided by Martin's researches on the embryology of the brain in the cat. Incidentally, important contributions have been made to a true appreciation of the morphological significance of the septum lucidum of the higher Eutherian brain.

[2] This is in apparent contradiction to the results of H. F. Osborn's researches

When we examine the brains of Eutherian mammals in the light of the foregoing facts, we find that throughout this Section, the regions of the mid-brain, the pons varolii, and the medulla
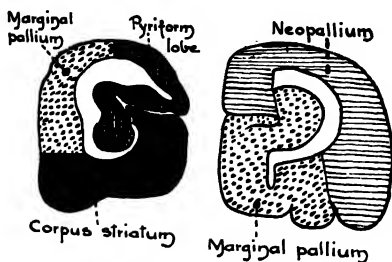
Fig. 234.   Fig. 235.

Fig. 234. Coronal section through the cerebral hemisphere of a Reptile (Hatteria). Differences of shading demarcate the marginal pallium from the pyriform lobe, and the corpus striatum. The neopallium is developed between the two former portions of the cerebrum, and is indicated very vaguely (for its extent is not actually known) by a dark band at the junction of the marginal pallium and pyriform lobe.

Fig. 235. Coronal section through the cerebral hemisphere of a lowly Mammal (Ornithorhynchus: Prototheria) shewing the limits of the marginal pallium and the neopallium (cf. Fig. 236). The corpus striatum does not appear in this section, and the pyriform lobe is merged in the lower part of the marginal pallium. The mesial aspect (as in Fig. 234) is to the left.

oblongata persist in a remarkably stable condition. With regard however to the telencephalon we find a considerable range of variation, the general nature of which may (as has already been indicated) be briefly described as consisting in progressive reduction of the rhinencephalon (as defined by Elliott Smith, *v. supra*) and its commissures, with increase in the neopallium, and its commisural tract, the corpus callosum. Increase in the neopallium

(cf. Minot, *Human Embryology*, pp. 684 *et seq*). Osborn claims to have demonstrated the presence of the corpus callosum in Birds, Reptiles, and Amphibia, and believes that it will be shewn to exist in Fishes. But a comparison of Osborn's descriptions (*op. cit.*) with those of Elliott Smith (*Linn. Trans.* 1900, Vol. VIII. p. 47 *et seq.*, see also foot-note No. 1, p. 398) leads one to believe that the commissure described by Osborn as the corpus callosum in the lower forms, corresponds to what Elliott Smith calls the dorsal commissure, a precursor of the (typically Eutherian) corpus callosum. At the same time, Elliott Smith, as will be seen in the preceding note, considers that the dorsal commissure is composed of hippocampal fibres only, whereas the primitive corpus callosum, according to Osborn, would contain neopallial fibres. So that the correspondence is not exact.

implies increase in that portion of the wall of the cerebral vesicle from which it is derived, and of that wall the external or superficial part is chiefly affected. The superficial limits of the basipallium, the marginal pallium, and the dorsi- or neopallium are indicated in part by certain cerebral fissures, known as the rhinal and the hippocampal fissures respectively, which are most easily recognisable in the brains of the most lowly mammals. (Cf. Fig. 236.)·

Fig. 236. Mesial aspect of the right cerebral hemisphere of a lowly Mammal (Ornithorhynchus : Prototheria). The rhinencephalon and marginal pallium are shaded to distinguish them from the neopallium. The limiting fissures, viz., the rhinal and hippocampal fissures are shewn : and the dorsal and ventral commissures are seen to be unaccompanied by a callosal commissure. Cf. also Figs. 234 and 235.
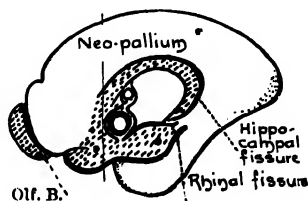
Fig. 236.

When, in consequence of the requirements of the animal, the neopallial surface increases in extent, it is thrown into folds, so that the fissures on the cerebral hemisphere to which reference has just been made, are supplemented by furrows formed on the surface of the neopallium. It will be noticed, however, that these furrows have a morphological significance and value quite distinct from those of the rhinal and hippocampal fissures, which nevertheless persist and are still recognisable, however great the development of the neopallium, and however complicated the system of neopallial furrows may be. The brains of most of the Eutheria, and of the Primates in particular, including the Hominidae, are characterised by the possession of a number of such neopallial furrows, which divide up the neopallial surface into a series of convolutions familiar to students of the human cerebral anatomy, while at the same time the rhinal and hippocampal fissures persist and demarcate the basipallium from the marginal pallium, and the latter from the neopallium.

When we pass from the study of brains with non-furrowed (or non-convoluted) pallia to that of brains in which the furrows, and the convolutions bounded by them, are numerous, the question arises, whether or not there is a single primitive type of the convoluted neopallium, of which all other convoluted neopallia

are the more or less modified outcome. The answer to this question seems, from the stock of evidence at present available, to be in the negative. Investigations into these questions take us far beyond the limits of the Order Primates, and in the present place only a brief statement of the results of some of the researches that have been carried out in the Mammalia can be given.

In the succeeding paragraphs some of the factors by which the increase (with consequent folding) of the neopallium is determined, will be considered, though not in order of importance, as to which there is so far no criterion[1].

In the first place it appears that the habitat and the mode of life of an animal react on the conformation of the neopallium ; for in relation to these stands the development of the several senses ; now the sense-organs find in the superficial portions of the neopallium, representation over a certain area which will vary in extent with the employment of the organ, and this will to some extent at least be modified, as we have suggested, by the environment of the particular animal.

Secondly, the absolute mass of an animal exercises an influence upon the extent of surface needed for the appropriate representation (upon the neopallium) of the various senses, in accordance with the well-known fact that while the bulk of a spherical organ (to which the brain may be compared) is increased in the ratio of the cube of its radius, the area of its surface is increased in the ratio of the square only of that radius. Therefore of two animals of equal sensitiveness (using the term in the widest significance), the one, if minute, can provide the requisite extent of cortex upon an almost smooth neopallium, while the second and larger form will need perhaps a very high degree of convolution to increase the cortical surface to the appropriate amount.

Thirdly, though by no means least, the status of the animal as regards morphological evolution has to be taken into account. For it appears that certain animals, even when due allowance has been made for (1) environment, and (2) for their mass, are still

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[1] The chief researches to be studied in this connection are (1) Manouvrier, *Mém. de la Soc. d'Anth. de Paris*, 2ᵉ Série, t. III. 1885, pp. 137—326. (2) Dubois, *Bull. de la Soc. d'Anth. de Paris*, 4ᵉ Série, t. VIII. pp. 337 *et seq.*

provided with an excess of neopallium, as compared with other animals for which the corresponding allowances have been made. Such an excess of neopallium may or may not be referable to the possession of distinct faculties or senses: these we must for the moment leave out of account, only remarking that the surplus of neopallium is accommodated by folding of the surface, just as though it had been provided in response to either of the two requirements (environment and mass) first described.

The following considerations arrest us at this stage of our enquiry; (1) on the one hand, we find in every Order of the Mammalia (or the Eutheria, for it will be simpler for the moment to restrict the range of study to these) examples of animals (*a*) of varying habitat, and (*b*) of minute and of great mass respectively. We shall therefore not be surprised to find that even within the limits of any one of these (Eutherian) Orders, a series of brains can be demonstrated, in which are represented all grades of complexity in the arrangement of the neopallial furrows (and convolutions), varying from an almost absolutely smooth surface upwards. The primitive type of neopallial surface is apparently a smooth, unfurrowed one[1].

From such a smooth neopallium, evolution in the Eutheria has resulted in the production of furrowed and convoluted modifications of several kinds, so different in their terminal stages (as represented by existing forms of Eutheria) as to render the determination of the homologies of most of the furrows 'a matter of considerable difficulty. It is noteworthy that within the limits of each of the several Orders of Eutheria (as established in accordance with the definitions laid down in an earlier chapter), there is a general resemblance of type in respect of the arrangement of these furrows, and by selecting a series of examples from one Order, the evolution of the combination of furrows characteristic of that Order can in many instances be demonstrated, starting from a form (still within the Order) in which the neopallium is primitively smooth. This statement holds good for the Primates, and consequently it follows that within each Eutherian Order the factors already mentioned have to be taken into account, and in

[1] Among the numerous paradoxes in this subject the presence of a well-convoluted neopallium in Echidna (Prototheria) is not the least striking.

addition, consideration of the influence of mechanical factors acting upon the form or proportions of the brain-case must not be omitted.

(2) Secondly, we find even from very superficial inspection, that in the Hominidae, the encephalon is modified in the same way as the corresponding organ in the Primates; and hence the association of the Hominidae with these Eutheria receives its final confirmation. But further, the members of this same Order of the Primates present us with the most striking examples of Eutheria 'in which the amount of neopallial extension is in excess of what would appear to be demanded by (what may be regarded as) the comparatively lowly claims of development of sense organs, and of actual mass. This phenomenon may be expressed by describing the "cephalisation" of the Primates as in excess of that of other Eutheria.

In the Primates too we find, in accordance with the statements just made, that it is possible to demonstrate a series of brains, the neopallial characters of which range in complexity from the smooth unfolded organ of Tarsius, to the highly convoluted one of the Hominidae.

An attempt to trace the homologies of the several constituents of the encephalon in general, and of the characteristic neopallial furrows of the Hominidae, through the Eutherian series would take us beyond the scope of the present account, which is therefore limited to the consideration of a few selected features of morphological interest. It is proposed therefore to deal briefly in succession with the

(a)   rhinencephalon.

(b)   marginal pallium.

(c)   neopallium, especially as regards the operculation of the insula, and the sulci and gyri adjacent to it.

(d)   the principal neopallial sulci.

(a)   rhinencephalon. In the human brain the representative elements are,

(1)   The olfactory nerve fibres and bulb.

(2)   The olfactory nerve, an attenuated representative of the tractus olfactorius of primitive mammals: this attenuation is, as has been mentioned, very characteristic of the brains of

26—2

Anthropoidea, which thus differ markedly from those of Lemuroidea: in the latter the more primitive mode of conformation obtains.   (Cf. Fig. 37.)

The reduction occurs as it were suddenly, in the transition from Lemuroidea to Anthropoidea, and is undoubtedly associated with the great neopallial increase in the latter Sub-order.

(3)   The "external root" of the olfactory nerve marks the course of the olfactory tract, which is thus traceable outwards across the Sylvian vallecula, then skirting the anterior perforated space (a tuberculum olfactorium being indistinguishable, so flattened has the surface become locally), to be lost in the anterior extremity of the "uncinate gyrus": in this anterior part, which is absolutely distinct from the posterior part of the uncinate gyrus, is recognised all that represents (in the Hominidae) the pyriform lobe.

The exact demarcation between the olfactory tract and pyriform lobe remains to be determined.   Elliott Smith[1] speaks of the "radix lateralis" of the olfactory nerve as representing the anterior part of the pyriform lobe in Man, and an absolutely precise delimitation would probably be determined by histological observations.   About the middle of intra-uterine existence, the developing cerebrum shews the clearest evidence of the continuity of the tract with the anterior part of the uncinate gyrus, a continuity which is subsequently to a large extent obscured. (Cf. Fig. 237.)

(4)   The septum lucidum and the gyrus subcallosus represent the primitive corpus paraterminale: the former is recognisable in the Hominidae as in the Primates in general, and varies in the latter with the extent of the corpus callosum.

(5)   The anterior commissure of the human brain represents the primitive ventral commissure, traceable as such throughout the Primate series.

(b)   (1)   The hippocampus major, the band of Giacomini, the fascia dentata, the fimbria and fornix are the foremost representatives of the marginal pallium, and are traceable throughout the Primate series.   In the Hapalidae it is noteworthy that the fornix commissure is very small and placed far forward near the anterior

[1] *J. A. and P.* Vol. **xxx.** p. 199.

commissure. (Beevor, quoted by Elliott Smith, *Linn. Trans.* VIII. 10, p. 332, Relation of the Fornix to the Margin, etc.; *J. A. and P.* Vol. XXXII. Fig. 23.)
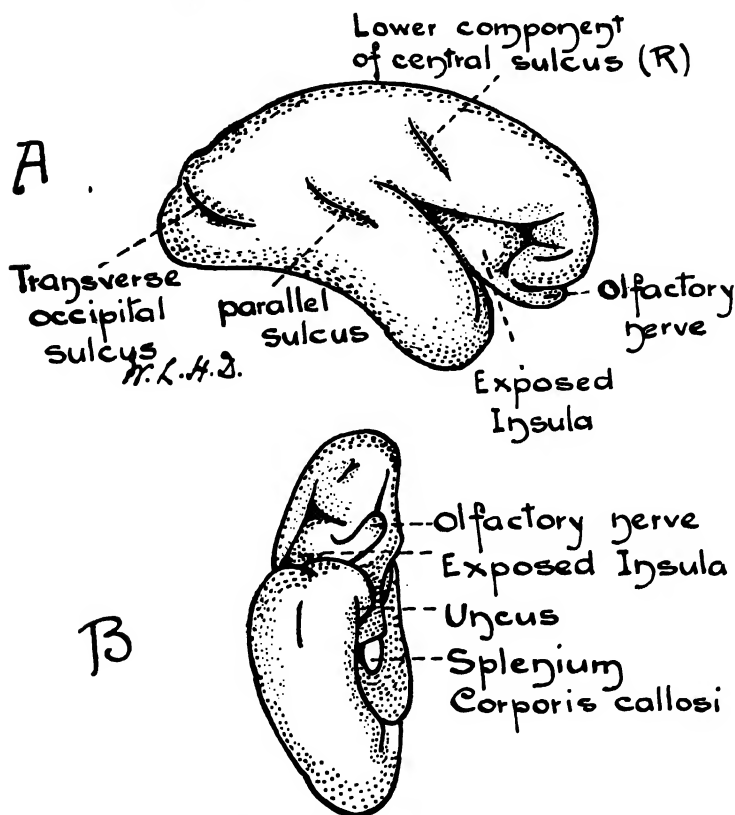
Fig. 237. Lateral (A), and basal (B) views of the right cerebral hemisphere of a human foetus of five months. In (A) the transverse occipital sulcus is an artefact.

(2) The small "Balkenwindung" (or gyrus A. Retzii), the striae Lancisii, and the gyrus geniculi are all referable to the marginal pallium. The former structure (Balkenwindung) is distinctly less evident in the brains of the lower Primates than in the Hominidae. Elliott Smith[1] quotes Zuckerkandl's description of this structure in the Lemuroidea[2].

[1] *Linn. Trans. loc. cit.* p. 331.

[2] "Beitr. zur Anat. des Riechcentrums." *Sitz. Akad. Wiss. Wien. Math.-nat. Cl.* Bd. CIX. Abth. iii. 1900.

The incisura temporalis represents the posterior part of the rhinal fissure: it is situated in the Hominidae and higher Primates on the ventral aspect, but in the lower Primates (Lemuroidea) on the lateral aspect of the hemisphere. The collateral sulcus does not represent any part of the rhinal fissure. Elliott Smith[1] states his view most categorically on this point, confusion on which is attributable partly to the inclusion of rhinencephalon (pyriform-lobe-constituent) and neopallium in the comprehensive term "uncinate gyrus[2]." Having thus accounted for such parts of the cerebral hemisphere of the Hominidae as are referable to the rhinencephalon, attention may be transferred to the neopallium.

(c) In the Hominidae, the neopallium is to be considered as responsible to a large extent for the characteristic form of the cerebral hemisphere. Thus the fulness and rounded appearance of the hemispheres, and the degree to which the cerebellum is overlapped by them, are attributable to this factor, though as regards the latter character (the cerebral overlap), the Hominidae are surpassed by a comparatively lowly member of the Anthropoidea, viz. Chrysothrix, a genus of small new-world monkeys (Cebidae). It is thus evident that even this character does not confer upon the Hominidae a position apart from all other Primates: nor indeed can the character of the possession of a posterior cornu of the lateral ventricle, for this (cf. Elliott Smith, *Cat. of the Museum of the Royal College of Surgeons*, Phys. Series, Vol. II. p. 384, and *Linn. Trans.* 1903, Vol. VIII. Part 10, pp. 379, 380, 381), though admittedly not present in the Lemuroidea is a feature of the brains of the lowest Anthropoidea, viz. the Hapalidae.

(d) The complicated arrangement of sulci and convolutions of the surface of the neopallium of the Hominidae remain for consideration. The degree of complexity of these sulci constitutes a distinguishing feature of the Hominidae within the Primates. It may however be remarked that not even in virtue of the combination of so highly convoluted a neopallium together with a much reduced rhinencephalon, do the Hominidae stand at the head of the Eutherian series, for in respect of this combination, believed at one time to be their absolutely distinctive attribute,

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[1] *Linn. Trans.* 1903, Vol. VIII. Part 10, p. 390, footnote.

[2] Elliott Smith, *op. cit., loc. cit.*

the Hominidae are surpassed by certain Cetacea, in which both characters (viz. complexity of convolutions, and reduction of rhinencephalon) have advanced to a further stage than in the former.   Due allowance being made for this consideration, it remains to review the characters and disposition of the sulci and convolutions, commencing with the region of the central lobe or Island of Reil.   This part of the neopallium, when traced through the Primate series, will be found to lose the complexity of surface due to the sulci which indent its surface in the Hominidae and Simiidae.   In the lower Anthropoidea and Lemuroidea, it presents the aspect of a smooth eminence of neopallium from which the frontal, and in turn the orbital opercula are withdrawn as the type recedes further from the Hominidae, while the temporal operculum persists throughout the Order.   Reduced thus to its simplest terms, the central lobe is revealed as a portion of the neopallium, closely related and attached to the corpus striatum: research extended beyond the limits of the Primates, indicates that this localised retention is accompanied by a downward flexion of the portion of that part of the neopallium which lies posteriorly to the fixed area.   Similar research shews (cf. Elliott Smith, *Cat. Mus. R. C. S.* p. 368) that this flexion results in the production of a furrow or group of furrows upon the surface of the fixed area, and immediately above the rhinal fissure.   This furrow (or the combination of a group thus developed) is well-marked in Carnivora, in the brains of which it has been described as the "pseudo-sylvian fissure[1]."   (Cf. Fig. 238.)

Above and anteriorly to the fixed area, is found (in Carnivora) a sulcus called the supra-sylvian, which with the post-sylvian sulcus (Fig. 238), forms one of a system of furrows concentrically arranged in tiers above the fixed area.   The brains of Lemuroidea shew that the supra-sylvian and pseudo-sylvian furrows join, and the area included between them is the central lobe, insula, or Island of Reil, the superior limiting sulcus of which is seen to be the modified derivative of the supra-sylvian sulcus, while the posterior limiting sulcus represents the pseudo-sylvian furrow, and the parallel sulcus the post-sylvian furrow.   But for the demonstration in

[1] Elliott Smith, *Catalogue Mus. R. C. S.* p. 368, and *J. A. and P.* xxxvi. p. 312. Holl's work.
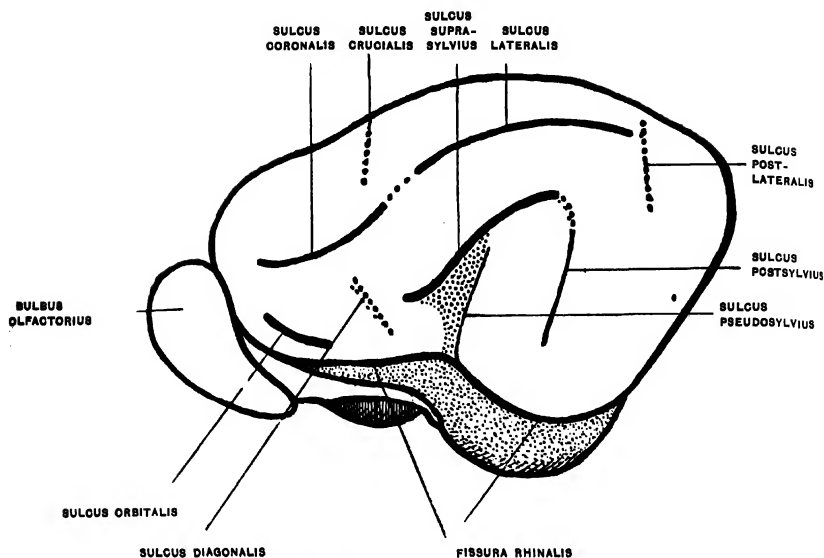
Fig. 238. Lateral aspect of a cerebral hemisphere upon which are indicated the most constant of the neopallial furrows found in the Eutheria. The pseudo-sylvian and supra-sylvian sulci are to be particularly noticed. (This and the following illustration are kindly lent by Dr Elliott Smith.)
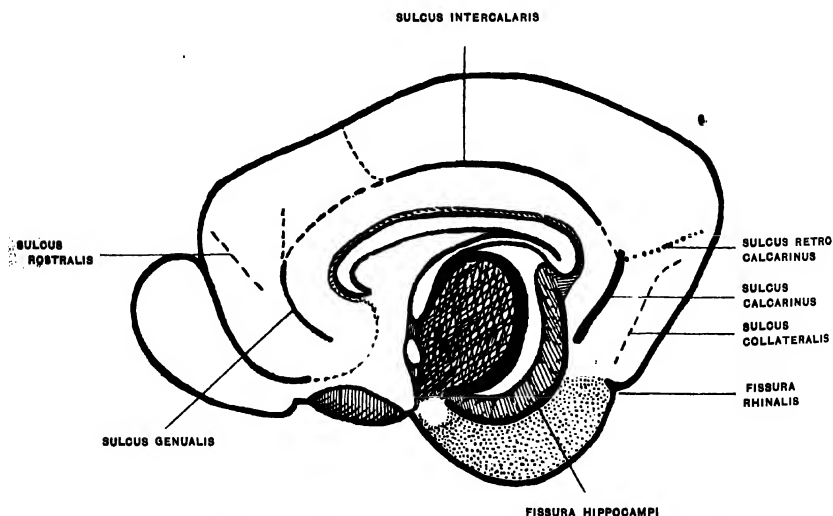
Fig. 239. Mesial aspect of a cerebral hemisphere upon which are indicated the most constant of the neopallial furrows found in the Eutheria. The calcarine and intercalary sulci are to be particularly noted.

detail of these points reference must be made to the masterly work of Elliott Smith. It remains to add that the central lobe of the Hominidae is bounded further by an anterior limiting sulcus; in the Simiidae this is recognisable in the fronto-orbital sulcus, which in turn is regarded by Elliott Smith as homologous with the sulcus diagonalis of lower forms; but neither the fronto-orbital sulcus, nor other representative of the sulcus diagonalis (Fig. 238), can be traced in the Primates (excepting some Lemurs) lower than the Simiidae (unless indeed an offshoot of the orbital sulcus is called in question: there is some evidence in support of this). Tracing the evolution upwards, the neopallial surface on the distal sides of each of these limiting sulci of the island of Reil becomes opercular in turn, that portion which lies beyond the pseudo-sylvian (between it and the post-sylvian) first increasing, next that beyond the fronto-orbital sulcus (the anterior limiting sulcus of Reil), and lastly that beyond the supra-sylvian sulcus (the superior limiting sulcus of Reil); the latter increase is associated with an increase in tortuosity, though not in relative mass, of the inferior frontal convolution, progress in evolution being here demonstrable by the comparison of the brains of Simiidae with those of the Hominidae. Of the sulci just mentioned, it may be remarked that the supra-sylvian is regarded as the most archaic, and as recognisable throughout a large series of Eutherian brains besides those of Primates, in all of which it is seen as the sylvian fissure. (Cf. Fig. 241.)

It will be convenient to arrange the notes dealing with the more important sulci in tabular form, commencing with the orbital or tri-radiate sulcus of human anatomy. (Cf. pp. 410, 411.)

The conclusion is that the whole Primate series leads up progressively to the type of brain found in the Hominidae.

With the accompanying table (pp. 410, 411) this section of the account of the cerebral hemispheres must be brought to an end. There remain the more posteriorly-situated constituents of the encephalon. Of these the trapezium will attract some attention: this band of fibres forms a commissure whereby the auditory nerve impulses may decussate, and in the Hominidae this band is not visible on the surface of the medulla oblongata. Such complete submergence of the trapezium is characteristic of the Hominidae,

Name in Human Anatomy	Appearance in the series of the Primates	Probable representative in lower Eutheria (cf. Fig. 241)
Tri-radiate (orbital) sulcus *.	This sulcus is practically constant throughout the Primates, though it is not tri-radiate in the lower forms (Lemuroidea). In some brains of Lemuroidea the sulcus is not present.	The orbital sulcus of the Primate brain is regarded as homologous with the pre-sylvian sulcus which is so distinct in the brains of some Carnivora.
Inferior frontal sulcus *.	This is represented by the sulcus rectus, a furrow well-marked in the Cercopithecidae, and recognisable throughout the Primates.	The homologue of the sulcus rectus is found in the sulcus coronalis of the brains of the Carnivora. This sulcus is one of early appearance in the Eutherian series.
Central sulcus (Rolando).	This furrow is recognisable throughout the higher Primates: it disappears, or is quite rudimentary, in some of the smaller Cebidae, and is absent in the Hapalidae; in the Lemuroidea, it is represented by a mere depression, except in Perodicticus, and certain extinct Lemurs (Globilemur and Nesopithecus).	The central fissure is identified (though there has been much discussion on this subject) with the sulcus crucialis which is so conspicuous in the brains of Dogs, Bears and other Carnivora. It does not seem clear which of the two elements from which the human central sulcus is embryologically developed, is thus represented.
Intra-parietal sulcus.	Recognisable throughout the Primates; in Chrysothrix (Cebidae) it blends with the sylvian fissure.	The intra-parietal is believed to represent the S. lateralis, while its ramus post-centralis superior is the S. ansatus of Carnivora.
Sulcus lunatus, or Affenspalte of German authors. Though recognisable in certain abnormal human brains (viz. those of some microcephalic idiots), the sulcus lunatus is commonly described as absent from the brains of the Hominidae,	Most distinct in the Simiidae, Cercopithecidae, and some Cebidae (Cebus), but in the smaller Cebidae, in the Hapalidae, and all the Lemuroidea it is deficient. It must be admitted that though distinct, the occipital operculum and sulcus lunatus of the Hominidae are degenerate or vestigial as compared with the corresponding parts in the Cercopithecidae, or even the Simiidae.	Not traceable beyond the Anthropoidea, in which the need for its development depends on the increased size and complexity of the occipital neopallium.

owing to the occipital operculum (to which it owes its existence) having been thrown back by convolutions emerging from the depths of the sulcus. Cunningham admitted the possibility of its occurrence in very rare instances, and Mendel (*Neurologisches Centralblatt*, Vol. II. p. 217) describes one such case and cites others.

Bischoff described (cf. Cunningham, *Cunningham Mem.* VII. pp. 66 *et seq.*) the ape-fissure as a transitory characteristic of the human foetal cerebrum, and named the sulcus thus considered homologous with the ape-fissure, the fissura perpendicularis externa. Elliott Smith has however recently shewn (*Anatom. Anzeiger*, Band XXIV. No. 8) that the fissura perpendicularis externa is really an artefact, and the result of the impression made upon the soft hemisphere, by an inward projection of the membrane in the lambdoid suture.

Elliott Smith (*Cat. Mus. Roy. Coll. Surg. London*) mentions the occurrence of the sulcus lunatus in the brain of a (normal) Egyptian native (*op. cit.* p. 473), and in a recent communication to the *Anatomischer Anzeiger* (Band XXIV.) adduces numerous instances of the occurrence in the brains of Egyptians, Soudanese negroes, and other lowly races. Statistics as to the frequency of occurrence of the sulcus are now being collected and notes upon the subject will be found in Chapter XIV. The sulcus marks the lateral limit of Gennari's stria. (Elliott Smith, *Anat. Anz.* XXIV. 16, 17.)

Name in Human Anatomy	Appearance in the series of the Primates	Probable representative in lower Eutheria (cf. Fig. 241)
Calcarine sulcus*.	Constant throughout the Primates. The portion which is represented by the projection of the calcar avis, on the internal aspect of the ventricle, may be supplemented by posteriorly-situated furrows which blend with this, the "true" calcarine sulcus.	Represented in almost every Eutherian order, the exceptions being the Insectivora and Rodentia. It forms part of a sulcus called, from its situation, the splenial sulcus.
Internal parieto-occipital sulcus.	This sulcus consists of a dorsal and a ventral element. Both are lost in the lowest Anthropoidea (smaller Cebidae and Hapalidae), and the internal parieto-occipital sulcus which is so evident in the Lemuroidea is justifiably regarded as the equivalent of the ventral component alone of that sulcus in the higher Anthropoidea. The sulcus is preferably named paracalcarine in the Lemurs.	No distinct representative of this sulcus can be recognised beyond the Primates, in which its appearance is associated with the increased extent of the neopallium at the occipital end of the hemisphere.
Calloso-marginal sulcus.	Recognisable throughout the Primates, and particularly well-marked in the brain of Cheiromys (cf. Figs. 239 and 240) (Lemuroidea); it is however deficient in Hapale (Anthropoidea).	As the "inter-calary" sulcus, it forms part of the splenial sulcus of Carnivora, etc.
Collateral sulcus	This sulcus is developed in response to the demands of increasing neopallial surface near the calcarine sulcus. It is intelligible therefore that it can only be traced down as far as the Cebidae, and that in the lowest Anthropoidea (Hapalidae), as in the Lemuroidea, it should be deficient.	The sulcus is possibly represented by small isolated sulci in some non-Primate brains, but no homology has been definitely established.

* The sulci thus marked, together with the supra-sylvian sulcus (the S. limitans superior of Reil) are the most archaic in the Eutherian series. (Cf. Figs. 238, 239, and 241.)
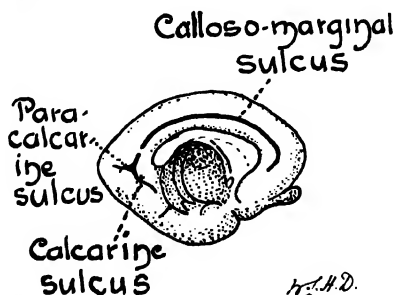
Fig. 240. The mesial aspect of the left cerebral hemisphere of Cheiromys madagascariensis: the calloso-marginal or intercalary sulcus is well-developed.

for in the Simiidae the trapezium is slightly exposed, and becomes fully visible in the Cercopithecidae.
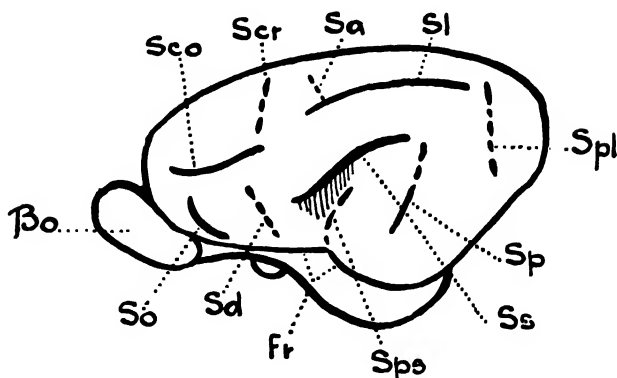
Fig. 241.   Diagram (after Elliott Smith) to represent the most constant and archaic sulci on the surface of the cerebral hemisphere of the higher mammalia.
The indications are as follows:

Bo: Bulbus olfactorius.   So: Sulcus orbitalis.
Sd: Sulcus diagonalis.   Fr: Fissura rhinalis.
Sps: Sulcus pseudo-sylvius.   Ss: Sulcus supra-sylvius.
Sp: Sulcus post-sylvius.   Spl: Sulcus post-lateralis.
Sl: Sulcus lateralis.   Sa: Sulcus ansatus.
Scr: Sulcus crucialis.   Sco: Sulcus coronalis.

The Cerebellum.   The morphology of the higher types of cerebellum is still under discussion, but a few remarks on recent contributions to this subject seem to be called for.   The system of nomenclature current in anatomical text-books has long been recognised as unsatisfactory, and indeed misleading in the enquiry into the morphology of the cerebellum, and an amended nomenclature was at an early period seen to be a prime necessity.   But while the human cerebellum was taken as the standard of comparison, the conceptions that prevailed as to the constitution of the organ were ill-defined and imperfect.   The attention of morphologists having been directed to the simpler mammalian forms of cerebellum, an amended nomenclature was soon proposed, and it is worthy of remark that this was based on the recognition of the identity and constancy of certain fissures which demarcate the component parts of the organ.   But the several schemes

proposed have not yet been reconciled, so that it is now necessary to review some of the more important of these.

Of the various contributors to a fuller knowledge of this subject Elliott Smith and Bolk stand out preeminently. While these writers treat principally of the comparative anatomy of the cerebellum, the embryological side has been studied by Bradley[1], to whom we owe a detailed exposition of the conflicting views that have been formed[2]. As a result of these researches, it appears in the first place, that unlike the cortex of the cerebral neopallium (which expands in several directions), the surface of the cerebellum tends to increase in two directions principally, expansion being practically confined to the sagittal and transverse axes of the organ.

In the former (sagittal) direction, expansion finds expression in a series of transversely-directed sulci, most distinct in the middle portion of the cerebellum; but in the lateral portions, expansion in a transverse direction accompanies sagittal expansion, and the sulci which indicate such increase of surface are accordingly arranged in a more complicated manner than in the mesial part of the organ.

In the mesial part, a particular sulcus was soon recognised as a definite morphological landmark. To this sulcus, which is transverse in direction, various names are applied, such as sulcus furcalis (Stroud), sulcus primarius (Kuithan), fissura prima (Elliott Smith). The cerebellum is hereby divided into anterior and posterior segments, separated by the sulcus, but the further subdivision of the cerebellar mass provides material for controversy.

Following on the recognition of the fissura prima, the separation of the floccular lobe (consisting on each side of a flocculus and a paraflocculus) as a morphological entity, must be mentioned as a step in advance. But again, opinions differ as to the connections of the floccular lobe and the intermediate mass of the cerebellum. Thus Elliott Smith[3] describes the cerebellum as composed of the two floccular lobes, and an intermediate portion subdivisible into three successive segments demarcated by fissures termed fissura

[1] *Journ. A. and P.* Vol. xxxvii.
[2] Cf. Bradley, *J. A. and P.* Vol. xxxviii. Part 4.
[3] *Journ. A. and P.* Vol. xxxvi.

prima and fissura secunda respectively. Between the floccular lobes and the intermediate portion pass copulae or bands. It should be noticed too, that this junction is held to be effected between the floccular lobes and the posterior portion of the intermediate mass. Bolk[1] has put forward a slightly different scheme, according to which the cerebellum as a whole is divided into an anterior portion separated by the fissura prima from a posterior portion. It is further stated by Bolk, that while the anterior portion is affected by a tendency to expansion which is sagittal in direction, acting on all regions of this portion alike, the posterior segment (behind the fissura prima) has been differently modified in growth; so that while its more mesial part has (like the whole of the anterior segment), expanded in the sagittal plane, its lateral parts have increased in both the sagittal and transverse directions. This leads to the distinction (in the posterior segment) of a median part (corresponding to part of the median vermis of the old anatomical nomenclature) and two symmetrical lateral parts. The transverse expansion of the latter accounts for the projection of the floccular lobes on each side. Further, the connection of the floccular lobes with the intermediate part is effected according to Bolk (who herein disagrees with Elliott Smith) in the region immediately behind the fissura prima. (Elliott Smith, *v. supra*, locates this connection further back.)

Such[2] are the two principal views on the subject of cerebellar morphology, and when the enquiry is directed to the features of the human cerebellum it will be realised, that in the first place, the fissura prima is clearly recognisable: the floccular lobes (para-flocculus and flocculus) are much reduced in the Hominidae as compared with the Cercopithecidae and lower Primates, the Simiidae occupying an intermediate position in this respect. The human cerebellum is further characterised by the exuberance of that lateral component of the posterior segment known as the lobulus ansiformis (crus primum)[3], while, as already mentioned, the more distal component of the same portion (which is recognised

[1] *Monatsschr. für Psychiatrie und Neurologie*, 1902.

[2] Elliott Smith's last paper (1903) in the *Monatsschr. für Psychiatrie und Neuro-logie* is not accessible to me.

[3] Bolk, *op. cit.* pp. 460 *et seq.*

in the floccular lobe) is attenuated.   The evolution of these characteristic features of the human cerebellum can be traced in the series of the Primates; some of the lowlier members of this Order, and particularly Tarsius spectrum, present an extremely primitive and undifferentiated form of cerebellum; the Galaginae provide examples of another interesting and intermediate stage in the evolution of the organ as found in the higher Primates.

It is thus noteworthy that the Order Primates is sufficiently comprehensive to include examples of almost every stage in the evolution both of the most highly complicated forms of cerebrum and of cerebellum.

The Spinal Cord.   When we pass from the study of the brain to that of the spinal cord we find the evidence more scanty and less accessible in the latter case.   In an earlier chapter mention was made of the distinctive feature of the Mammalia, consisting in the specialisation and increase in the encephalon, and hence it will be intelligible that the cord of mammals is relatively smaller in bulk (when compared to the brain) than in other vertebrates. This statement applies to the members of the Order Primates among the Mammalia, and to its significance allusion has already been made indirectly in the present chapter (p. 403).

Of the material available for a detailed comparison of the spinal cord of the Hominidae with those of their congeners and other mammals, the exhaustive essay by Waldeyer on the spinal cord of the Gorilla is by far the most instructive[1].   While arriving at the general conclusion that in its main features, including its histological structure, the spinal cord of the Gorilla so nearly resembles that of the Hominidae that for the purposes of comparison with the lower Eutheria the one cord would serve practically as well as the other, Waldeyer notes the following points as of prime importance among those brought to light in the course of his investigations.

The spinal cord of Man is most closely approached by that of the Gorilla, not only in its outward form and proportion, but also in the microscopical appearance of the transverse sections.   The

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[1] *Abhand. der Akad. der Wiss. Berlin*, 1888, III. pp. 1—147; Univ. Lib. Camb. 21. 5. 76.

human cord is however stouter and apparently relatively shorter in the thoracic region.

In absolute bulk, however, the cord in the Hominidæ is the greater (the comparison was instituted between individuals of approximately similar age). The contrast is marked even in the cervical region, and is the more striking, since the upper extremities of the Gorilla being more precocious in development, and attaining finally a higher degree of specialisation (in certain respects) than those of Man, would seem to demand an increased supply of nerve fibres which we might reasonably expect to see represented by a cervical enlargement of great size. But the superiority of the human cord in this respect throws the observer back on the consideration that the number of fibres, and the consequent size of the cervical enlargement of Man, are expressive of the large number of fibres supplied by the brain in anticipation of the future development of "skilled movements."

In actual shape when viewed in transverse section, the human cord differs from that of the Gorilla, the maximum transverse diameter in Man passing through the central canal, and the contour being more rounded than in the Gorilla, in which the maximum transverse diameter will be found to fall anteriorly to the central canal. Finally, the lateral cornua of the grey matter of this (cervical) region are more pronounced in the human cord.

In the thoracic region (besides the feature already mentioned) the appearance in transverse sections is instructive. In Man both cornua of grey matter are more slender and run out further from the central canal than in Gorilla. In the latter the posterior cornua have a particularly truncated aspect in comparison with those of Man, the intermediate grey matter also extending further from the centre of the cord than in the latter. In this respect the cord of the Orang-utan presents appearances closely resembling those of the cord of the Gorilla[1].

On the other hand, the nucleus dorsalis (Stilling) presents differences of conformation and position: in Man, it is situated at the inner margin of the posterior horn of the grey matter, and presents an elliptical contour, the long axis of which is approximately sagittal in direction. In the Gorilla the nucleus is much

[1] Cf. Rudolph Fick, *Abhand. der Akad. Berlin*, 1899—1900, p. 36.

nearer the central canal; it is elliptical in contour, and the long axis is more nearly transverse than coronal in direction. It is noteworthy that Pick (quoted by Waldeyer, *op. cit.* v. p. 415 *supra*) has recorded an example of a human cord in which the nucleus dorsalis resembles that of the Gorilla in respect of the above features.

Again, Clarke's column (represented in section by the nucleus dorsalis) in the Hominidae is closely approached by that of the Gorilla. On this subject the well-known work of Mott[1] on the comparison of the spinal cords of Man, a Macaque and a Dog may be cited. ' In Man, the cord is distinguished by the concentration of the cells of the column of Clarke, at the lower thoracic and upper lumbar region. In the lower forms of mammals just mentioned (Macacus monkey and Dog), the column is more evenly distributed throughout the dorsal region and upper lumbar region[2]. The exact significance of the contrast between the Hominidae and these lower mammals has so far merely been surmised. The exact connections of the cells of the column, though long suspected and for some time partly known (so far as their relation to the viscera are concerned), have only been recently (so far as their cerebellar relations are in question) completely demonstrated[3]. The surmise in question, is that of Ferrier to the effect that the system may be developed in relation to the erect attitude and equilibration, in view of the association of the viscera and of the cerebellum with these functions.

It must be added that Waldeyer detected in the cord of Gorilla, an indication of its intermediate position, inasmuch as the arrangement of Clarke's column, though more like that of Man than that of the Cercopithecidae, did not present the human characteristic, viz., the lumbar development of that column, in its highest degree.

Passing from the comparison of the spinal cord of the Hominidae with those of lower Eutheria in general, to the comparison with the Simiidae in particular, the only evidence at present accessible is that provided by H. Virchow[4] on the comparison

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[1] *J. A. and P.* Vol. xxii.

[2] Cf. Mott's figures, *op. cit.* p. 483.

[3] Cf. Laura, quoted by Barker, *The Central Nervous System*, p. 584. •

[4] *Anat. Anz.* 1888, No. 18, p. 509.

of the cords of the various forms of the Simiidae. The result of that comparison is to shew that Man is most closely resembled by the Gorilla, which in turn is more closely allied to the Hominidae than to the Chimpanzee, a surprising result which certainly requires confirmation from the evidence of several examples. Next to the Chimpanzee comes the Orang-utan, while all three apes are (like the Hominidae) very distinct from Hylobates. Rudolf Fick[1] has pointed out several features in which the cords of the Gorilla and Orang-utan agree (*op. cit.* pp. 35, 36); the same author has made elaborate observations on the histology of the neuroglia in the cords of Cebidae, Cercopithecidae, and Simiidae, and promises the publication of his recent researches by the method of staining with methylene-blue (intra vitam). From the evidence of comparative morphology, the association of the Hominidae in a natural order with the other Primates, and especially with the Simiidae, is thus seen to be confirmed.

II. **Embryology.** The embryological evidence of the brain of the Hominidae points in the same direction as that of comparative morphology, though, as has already been remarked, the details of evidence are wanting. We have seen that so early as the seventh week of embryonic life, the human brain begins to surpass that of the Simiidae in size, nor will this early difference be a matter of surprise, in view of the difference in bulk which distinguishes the organs at the completion of growth. There remain but a few points for special mention in this connection.[4] In the first place, the connection of the olfactory tract and pyriform lobe may be seen in the brain of the human embryo at the fifth month as clearly as in any of the Lemuroidea. (Cf. Fig. 237.)

Secondly, the ontogenetic development of the corpus callosum, in succession to the earlier dorsal commissure, has been demonstrated. (Cf. Mihalkovics and Marchand, quoted by Minot, *Human Embryology*, p. 683.)

Elliott Smith[2] notes that the supra-callosal part of the hippocampus major is visible in the brain of the human foetus at the 7th month (cf. Fig. 242). The same author has recorded[3] a case

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[1] *Abhand. der Akademie*, Berlin, 1899—1900.

[2] *Cat. Mus. Roy. Coll. Surg.*, London, 1903.

[3] *J. A. and P.* Vol. xxxviii, p. 158.

in which the normal condition of the insula (exposed anteriorly, and limited by a fronto-orbital sulcus) in the Simiidae, is exactly reproduced in a human foetus (Egyptian) of about 8 months.   Elliott Smith remarks however that such an exact reproduction is very rare.
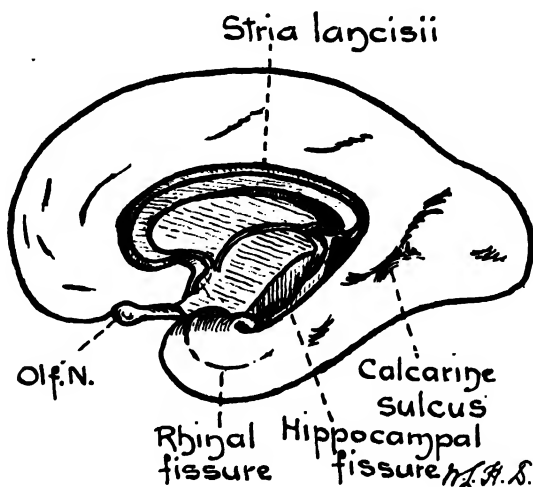
Fig. 242. Mesial aspect of the right hemisphere of the brain in a human foetus at the sixth month : shewing the supra-callosal part of the hippocampus as the stria lancisii.

Thirdly, the effects of the increased extent of the neopallium, in the direction of producing furrows and convolutions upon its surface, is generally admitted, and has formed the subject of numerous memoirs, of which that of Cunningham[1] is of especial value.

The balance of opinion now ascribes the so-called "transitory fissures" (which have been observed on the surface of the hemispheres of embryos of the third to fourth months, though they are subsequently lost) to the results of imperfect preservation of the specimens; these fissures possess consequently no morphological value, and will not be further discussed in this place.   It may however be remarked, that there is not yet complete agreement of opinion regarding certain fissures that have been thus observed,

Cunningham Memoir, VII.

and that Professors His and Hochstetter in particular, were in disagreement on several points connected herewith[1].

Some other data relative to the features of the encephalon in the Hominidae at two different stages of intra-uterine development, will be found in Chapter VI.

· III. **Racial Variation.** We now come to the variations of the encephalon found within the limits of the Hominidae, and must first of all remark that in addition to the study of the actual conformation of the organ, evidence of a comparative nature has been sought in the study of the weights, either of the whole encephalon, or of its constituent parts.

The space available does not admit of a discussion of the results of observations on the brain-weights of the Hominidae and other Primates, and a further excuse for this deficiency may be found in the plea that the primary object in view is the discussion of morphological conformation, of which weight is but a vague and indefinite function. This method of investigating the differences between animal forms is none the less valuable. As regards the Hominidae, reference may be made to numerous tables and charts, in Donaldson's *Growth of the Brain* (in the Contemporary Science Series), to Thane's records (in Quain's *Anatomy*, Vol. III. Part I.), and to the statistics recently published by Marchand and Bolk[2].

In addition to these, the following notes may be appended here. The great cerebral development of the Hominidae will be surely demonstrated by the weight of the brain, whether in comparison with that of the spinal cord, or that of the whole body. It may be noted that the brain weight of the (white) Hominidae is about $\frac{1}{36}$th part of the total body weight, and this ratio affords an instructive means of comparison between the Hominidae and other animals; in an adult Gorilla for instance the ratio is $\frac{1}{220}$ approximately. But it is noteworthy that while the higher Primates differ markedly herein from the Hominidae, the (lower) Cebidae, such as

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[1] Cf. His, *Die erste Entwickelung des menschlichen Gehirns*, Leipzig, 1904. Hochstetter, *Beiträge zur Ent. des Gehirns. Bibliotheca medica*, 1898. Goldstein, *Archiv für Anatomie und Physiologie*, 1903, Anat. Abth. : also *Anat. Anz.* Band XXIV. No. 22, pp. 529 et seq.

[2] *'Abhand. der kön. Sächs. Ges. der Wissenschaften*, XXVI. *Math.-phys. Kl.* XXVII. 1902. Bolk (*Petrus Camper*, Di. II. Afl. 4).

Chrysothrix or the Hapalidae, more nearly approach the Hominidae in this respect.   Numerous data are given, and their significance fully discussed by Dubois in the paper already quoted in this chapter (p. 401, footnote).

It will be evident in the next place, that in the search for data regarding the various human races, great lacunae remain to be filled so far as the more primitive of these are concerned.   In the absence of actual brains, this has led to various attempts to infer the brain-weight from the corresponding cranial capacity, and the method of arriving at the most correct estimate of the latter quantity has been indicated in a preceding Chapter, XI. (p. 274); the employment of such a method is of course absolutely necessary in the case of fossil specimens, whether human or other.

Manouvrier[1] shewed that the brain-weight is approximately obtained, when the value (in c.c.) of the cranial capacity is multiplied by the coefficient ·87.   Thus the equation may be represented as W (brain-weight in gm.) = C (cranial capacity in c.c.) × ·87 or

$$W = C \times x.$$

But the relation of the two quantities is not really so simple: as in the case of the stature in relation to the limb-bones (cf. p. 342), the more correct equation is of the form

$$W = C \times x + x'.$$

Evidently, then, the coefficient is a variable one, and the value ·87 quoted by Manouvrier is but an average value.   Welcker[2] has given several values for the coefficient, and the subject has been recently and fully discussed by Lee[3].

It may be pointed out, however, that while in virtue of superior weight of brain, whether this be absolute, or relative to his body weight, the Hominidae stand in a position of great eminence among the Eutheria, yet at the same time, there is no definite evidence that within the Hominidae, excessive brain-weight implies, or need be accompanied by, high intellectual ability.   So that neither brain-weight nor cranial capacity, nor the dimensions

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[1] *Mém. de la Soc. d'A. de Paris*, 2ᵉ sér. t. III. 1885, quoted by Thane in *Quain's Anatomy*, Vol. II., Part 1.

[2] *Arch. für Anth.* XVI. 51, quoted by Thane.   [3] *Phil. Trans.* 196 A. 1901.

of the head whence the foregoing may be inferred are directly useful as aids to assessing mental attainments.

Turning next to the spinal cord. Here we find, in the weight (whether absolute or relative) of the cord, evidence which demonstrates the exalted position of the Hominidae among the Primates. For the Hominidae, data are available in the published researches of Pfister[1] who has compared in many cases the weight of the human cord with the body weight. The final and characteristic proportion between the two would seem to be attained in the course of the first year of life.

Lastly, the corresponding comparison, or the comparison of the weights of the brain and the cord respectively, may be made with the aid of the method proposed by J. Ranke (and already described, Chapter XI. p. 277) of determining the capacity of the vertebral canal. Ranke's chief results have been indicated in the connection just mentioned, i.e. in connection with the osteometric section of this book, within which the method more properly falls.

Our attention must now be turned, as before, to the conformation of the brain, to which, as to other organs, strictly morphological considerations apply.

(1) The influence of age must be first reviewed. In the child at birth the human characteristics of the brain are already manifest, and have nearly attained their highest point of development. The central lobe is not in all cases completely overlapped by the opercula, but the rhinencephalon is much reduced, and the neopallium is marked by all the more important furrows which characterise the adult organ. Growth in absolute size is complete soon after the ninth year, at an epoch at which the general growth of the body is still far from completion.

(2) If the sexes be compared, no constant difference can be demonstrated between them, conferring upon either a morphological status superior to that of the other.

(3) In the various races of the Hominidae, one would expect some modification to be associated with the form of the brain, as shewn by the skull-form; ex. gr. it would not excite surprise if the arrangement of furrows and convolutions were found to be grouped in a different and characteristic manner in long-headed

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[1] *Neurol. Centralbl.* Band XXII.

and short-headed individuals respectively.   But although Schäfer[1] states that in the cerebral hemispheres of brachycephalic individuals, a tendency is manifested to the production of transverse divisions (in the convolutions), which is not shewn in the hemispheres of the brains of dolichocephalic individuals, yet it must be said that detailed evidence upon this subject has yet to be provided.

The cerebral characters of several representatives of the so-called "lower" races are now on record, but hitherto it has not been possible to arrive at any general conclusions regarding these, because of the lack of a conventional system of enquiry, and indeed of a consensus of opinion as to the special points that require investigation, and are the most likely to provide information which will determine the status of the specimen subjected to the research.

The difficulties of arriving at a general statement, which shall even approximately sum up the details of conformation in any one of these cases, are so great that observations have here been restricted to determining as far as possible the characteristic features in each group, of the following structures; (a) the rhinencephalon, (b) the central lobe or insula, and its more immediate surroundings, (c) the sulcus lunatus (or representative of the Affenspalte).   Several brains in the Anatomy Museum at Cambridge have been examined, and reference has been made to figures published in illustration of various memoirs.   The results of these observations have been appended in a series of brief notes.   In the present connection, the greater depth and distinctness of the rhinal fissure, the slighter tortuosity of the neopallial cortical folds, and the greater frequency of the retention of an occipital operculum and a sulcus lunatus, are points of prime importance, denoting the inferiority of the brains in which they occur[2].

Australian Aborigines.   Four brains of aborigines of Australia (cf. Figs. 243, 244, 245, 246) are in the University Museum of Anatomy at Cambridge.   The brains are all small, as indeed

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[1] Cf. Quain's *Anatomy*, Vol. III. Part I.

[2] The most complete bibliography of the comparative anatomy of the brain in the Hominidae is that given by Spitzka in the *American Journal of Anatomy*, Vol. II. 1903, p. 68.

is to be expected in the case of individuals of such small (average) cranial capacity as these natives.

Fig. 243.   Right cerebral hemisphere of an aboriginal of Australia (*Mus. Anat. Cant.*   W.L.H.D. photo.).
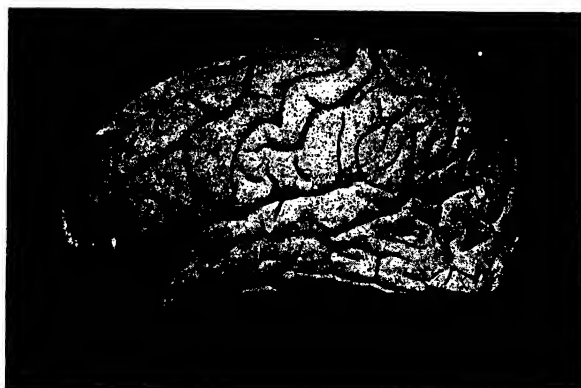
Fig. 244.   Left cerebral hemisphere of an aboriginal of Australia (*Mus. Anat. Cant.*   W.L.H.D. photo.).

The parts connected with the rhinencephalon provide material for the following observations.   In specimen No. 1 (Fig. 243), the rhinal fissure is distinct and boldly curved (cf. Elliott Smith's comments on this feature, *J. A. and P.* 1903, Nov.); in No. 2 (Fig. 244), the rhinal fissure is confluent with the collateral fissure; in No. 3 (Fig. 245), the rhinal fissure is distinct and the fasciola grisea (gyrus Andreae Retzii) is also well seen: the foregoing

remarks apply to both hemispheres of Nos. 1, 2, and 3; in the
right hemisphere of No. 3, the diagonal band of Broca is very
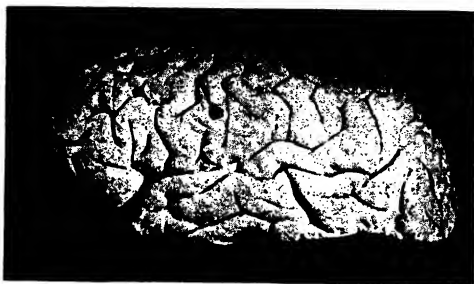
Fig. 245.   Left cerebral hemisphere of an aboriginal of Australia *(Mus. Anat. Cant.* W.L.H.D. photo.).

Fig. 246.   Right cerebral hemisphere of an aboriginal of Australia *(Mus. Anat. Cant.* W.L.H.D. photo.).

clearly seen, posteriorly to the anterior perforated space. In
No. 4 (Fig. 246) the fasciola grisea is large on the right side:
in the left hemisphere it has not been preserved: the gyrus
subcallosus is distinct on each side, and the rhinal fissure is boldly
curved.

The cerebral convolutions[1] are less tortuous than in the (larger)

[1] References to literature :

Rolleston, *Journ. Anthr. Institute*, 1887.
Miklucho-Maclay, *Proc. Linn. Soc.* N.S. Wales, Vol. viii.
Karplus, Obersteiner's *Arbeiten*, 1902.

brains of white men: of the four brains here considered, two are characterised by the incomplete submergence of the insula, since the opercula (especially the frontal operculum) are less exuberant than in the brain No. 4, in which the insula is not exposed. In all cases, however, all the opercula exist. One specimen (No. 1) is not sufficiently well preserved to supply definite evidence.

Particular attention was given to the occipital poles of these hemispheres, and in four out of the eight hemispheres the sulcus lunatus was recognised. (Figs. 247—254 incl. Also cf. Fig. 34.)

The detailed descriptions may commence with that of the specimen distinguished as No. 2 in the Museum Catalogue. As will be seen from the outline drawings, both hemispheres of this brain present a well-marked sulcus lunatus, bounding the remnant of the occipital operculum. Con-
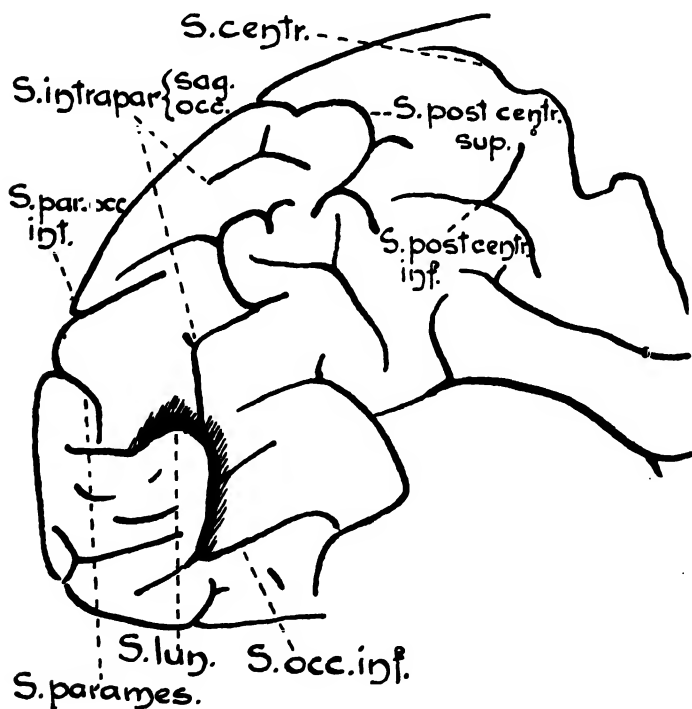
Fig. 247. Right cerebral hemisphere of an aboriginal Australian. The occipital convolutions are shewn (*Mus. Anat. Cant.* No. 2. W.L.H.D. del.). In this and the following figures *S. lun.* denotes the Sulcus lunatus.

sidering the right hemisphere (Fig. 247) first, the following characters are noteworthy :

(1)   The representative of the sulcus occipitalis transversus terminates beneath the operculum.

(2)   The sulcus paramesialis is independent of the sulcus lunatus.

(3)   The latter sulcus gives off a small branch—the sulcus praelunatus.

(4)   Superior and inferior occipital sulci are present.

Turning now to the left hemisphere (Figs. 244 and 248), the occipital operculum is seen with even greater distinctness: the following points are also noteworthy.
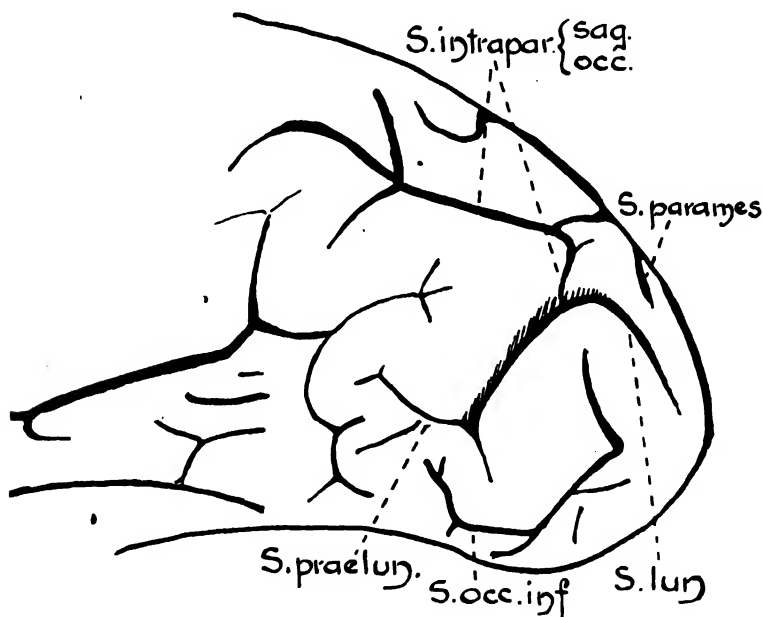
Fig. 248.   Left cerebral hemisphere of an aboriginal of Australia.   The occipital convolutions are shewn (*Mus. Anat. Cant.* No. 2.   W.L.H.D. del.).

(1)   The sulcus occipitalis transversus terminates in the sulcus lunatus, beneath its opercular lip.

(2)   The sulcus paramesialis is independent of the sulcus lunatus.

(3)   The sulcus praelunatus is present, and confluent with the sulcus lunatus.

(4)   Sulci occipitales superior and inferior are present, but confluent anteriorly.

Specimen No. 2 thus affords an excellent illustration of the occurrence of the occipital operculum in the brain of Man.

When we turn to specimen No. 3 (of the Cambridge Museum Catalogue) we find an equally good illustration of the condition in point.

The occipital end of the right hemisphere of No. 3 (cf. Fig. 249) has suffered some damage, and the appearances are, in consequence, not easy to interpret. It would seem as though the sulcus lunatus (*S. lun.*) were interrupted by a small gyrus emergent from its depth, so that the sulcus is divided into a mesial portion, whence a sulcus paramesialis arises, and a more lateral portion, giving off a sulcus praelunatus. If the foregoing interpretation is correct the sulcus occipitalis transversus just reaches the margin of the sulcus lunatus. The sulcus occipitalis superior is present in its typical form; and the sulcus occipitalis inferior is distinct and isolated.
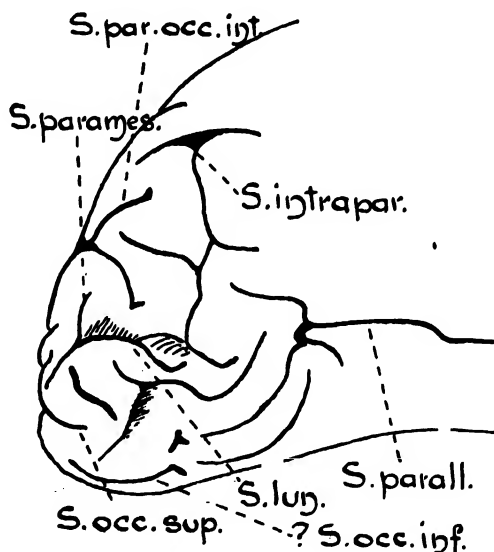
Fig. 249. Right cerebral hemisphere of an aboriginal Australian. The occipital convolutions are shewn (*Mus. Anat. Cant.* No. 3. W.L.H.D. del.).

With regard to the left hemisphere (Figs. 245 and 250), the occipital operculum is very distinctly seen (as has been said): the condition closely resembles that figured by Elliott Smith (*Anat. Anzeiger*, Bd. xxiv. Fig. 1) in the brain of an Egyptian Fellah. The following points may further be remarked:

(1) The sulcus occipitalis transversus just fails to reach the sulcus lunatus.

(2) The sulcus paramesialis takes origin from the sulcus lunatus. (Cf. Elliott Smith, *op. cit.* Fig. 1.)
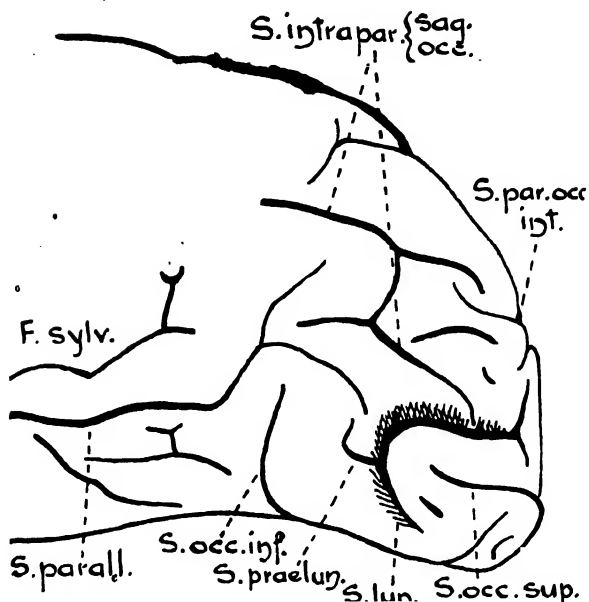
Fig. 250.   Left cerebral hemisphere of an aboriginal Australian.   The occipital convolutions are shewn (*Mus. Anat. Cant.* No. 3.   W.L.H.D. del.).
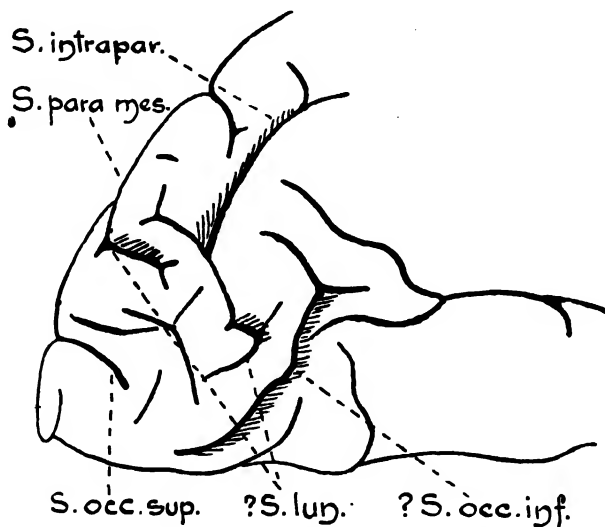
Fig. 251.   Right cerebral hemisphere of an aboriginal Australian.   The occipital convolutions are shewn (*Mus. Anat. Cant.* No. 4.   W.L.H.D. del.).

(3)   A sulcus praelunatus arises from the sulcus lunatus (Elliott Smith, *op. cit.* " a," Fig. 1).

(4)   Superior and inferior occipital sulci are present, and independent. The former has the typical " Y " shape of the corresponding sulcus in the Anthropoidea.

In the right hemisphere of Brain No. 4 (Figs. 246 and 251), the appearances are not very clear, but somewhat resemble those of the last-described right hemisphere.   As the correct interpretation, it is submitted that the sulcus lunatus (*S. lun.*) is interrupted, and that moreover the inferior occipital sulcus is very deep and opercular, overlapping the convolution on its lateral aspect, and thus compensating for the feeble operculation in the typical situation. According to this interpretation the following remarks are relevant:

(1)   The sulcus occipitalis transversus just reaches the lateral constituent into which the sulcus lunatus has been resolved by the emergent gyrus.

(2)   The mesial component of the sulcus lunatus gives off a sulcus paramesialis.

(3)   The lateral component of the sulcus lunatus gives off a sulcus praelunatus.

(4)   Superior, accessory, and inferior occipital sulci are present, the latter being very large and almost confluent with the parallel sulcus.

Turning to the left hemisphere of Brain No. 4 (Fig. 252), we again find a lack of definite information as to the identity of the several sulci, and again
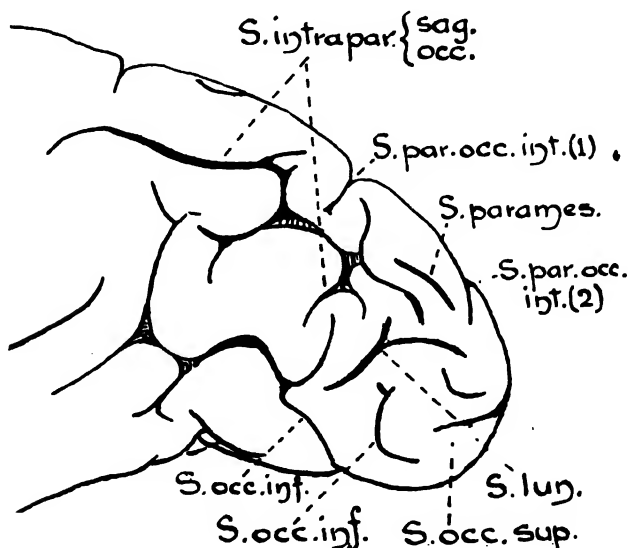
Fig. 252.   Left cerebral hemisphere of an aboriginal Australian.   The occipital convolutions are shewn (*Mus. Anat. Cant.* No. 4.   W.L.H.D. del.).

find a deep and operculated sulcus, which may be either part of the sulcus lunatus, or may represent the inferior occipital sulcus.

Brain No. 1 (of the Museum Catalogue) is much inferior to the other three in preservation, and the appearances are therefore more difficult to interpret than in the better-preserved examples. The right hemisphere (Figs. 243 and 253) may be first considered : it is not possible to recognise
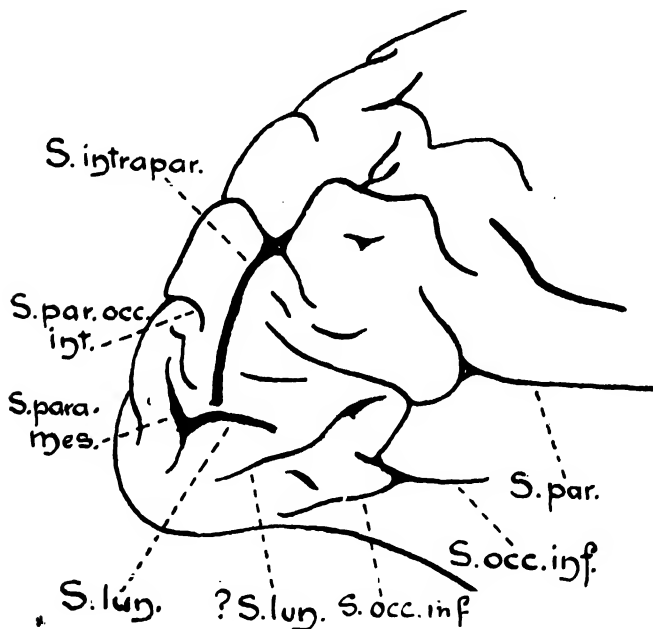
Fig. 253. Right cerebral hemisphere of an aboriginal Australian. The occipital convolutions are shewn (*Mus. Anat. Cant.* No. 1. W.L.H.D. del.).

either a definite operculum, or a continuous sulcus lunatus : the condition resembles that represented in Fig. 5 of Elliott Smith's paper (*Anat. Anz. loc. cit.*). The interpretation and the identity of the several sulci are indicated in the diagram (Fig. 253); the sulcus paramesialis appears to be present: close to it, part (*S. lun.*) of the sulcus lunatus seems to be combined with a superior occipital sulcus, while a long and almost rectilinear sulcus, more laterally placed (? *S. lun.*) looks like the un-operculated lateral part of the sulcus lunatus together with its offshoot, the sulcus praelunatus. It will be noticed that the intraparietal sulcus is not bifurcated terminally as the sulcus occipitalis transversus.

Turning to the left hemisphere (Fig. 254), the appearances are more definite: for there is a distinct (though small) operculated sulcus lunatus:

this is joined by the sulcus occipitalis transversus : no distinct sulcus para-mesialis is seen, and no sulcus praelunatus is present : the inferior occipital sulcus is very distinct, but the sulcus occipitalis superior on the contrary is obscure.
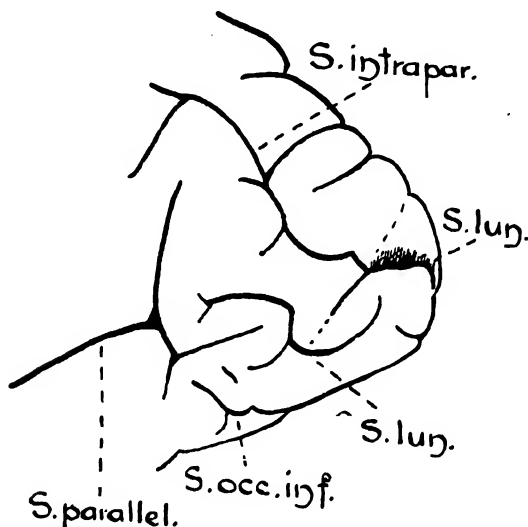
Fig. 254. Left cerebral hemisphere of an aboriginal Australian. The occipital convolutions are shewn (*Mus. Anat. Cant.* No. 1. W.L.H.D. del.).

It thus appears that in four out of these eight cerebral hemispheres of aborigines of Australia, a distinct occipital oper-culum is seen : in the remaining four hemispheres, the appearances are not so definite, nor can they be further classified. The sulcus lunatus is said by Elliott Smith to be present in the brain of the aboriginal Australian described by Karplus (in Obersteiner's *Arbeiten*, 1902)[1]. The lowly status of these aborigines is hereby clearly shown. Two points must be mentioned in conclusion ; (i) the deepening of the inferior occipital sulcus, where the occipital operculum has disappeared, may be compensatory in nature ; and (ii) the smallest brain of the four does not, as might have been expected, present the best example of an occipital operculum.

[1] The contention that the Affenspalte must bound an occipital operculum, beneath which are received the terminations of the intraparietal and internal parieto-occipital sulci, is hardly justified ; and the Simiidae would be deprived of this cerebral feature were the condition to be insisted upon.

Cerebellum. In one aboriginal Australian brain in the Cambridge collection, the cerebellum has been preserved, and the flocculi are not larger than those of the brain of the white races.

Brain weight. No data seem to be on record. Estimates may be obtained from the value (in c.c.) of the cubical contents of the cranium, but such results will be only approximations. Davis' estimate[1] was 1185 gm. (white men 1333 gm.). With the foregoing, the brains of Papuans and aborigines of New Caledonia should be associated. The only descriptions of Papuan brains are those furnished by Huntington[2].

African negroes.

Two brains of negroes are preserved in the Cambridge collection. They present the following characters. The rhinal fissure is as distinct and boldly curved as that recorded in the brain of an Egyptian Fellah[3] (No. 2, cf. Fig. 257); it is short and straight, while deep, in No. 1; the uncus in No. 2 is much recurved and resembles the uncus in Hylobates[4]. In both brains the fasciola grisea (gyrus A. Retzii) is distinct. In both brains the insula is practically quite submerged (cf. Fig. 255).

Fig. 255. Part of the left hemisphere of the cerebrum of a negro (No. 2) in the Cambridge Anatomical Collection. 1. Insula: almost completely submerged. The space left superficially to the insula was occupied by the pia mater and blood-vessels. *F*. frontal lobe, *T*. temporal lobe.

In three out of the four hemispheres, the sulcus lunatus is present (the remaining hemisphere has been mutilated locally, so as to render the identification of this feature impossible). Elliott Smith has observed this sulcus in the brains of Soudanese

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[1] Cf. Thane, Quain's *Anat.* Vol. III. Pt. I. p. 180. The sulcus lunatus is absent from two brains of natives of New Caledonia at Paris (*Mus. d'Hist. Nat.*).

[2] *American Journal of Anatomy*, Vol. I. p. 517.

[3] Elliott Smith, *Journ. A. and P.* XXXVII. p. 325.

[4] Cf. Zuckerkandl, *Zeitsch. für Morph. und Anthrop.* Bd. IV.

negroes. The flocculus in the negro brain does not seem appreciably larger than in the brain of the white man.

The accompanying figures (256, 257) shew the difference in the form of the uncus in the two negro brains; in No. 2 (Fig. 257), the remarkable mode of termination of the calcarine sulcus is noteworthy for it turns outwards, not inwards.
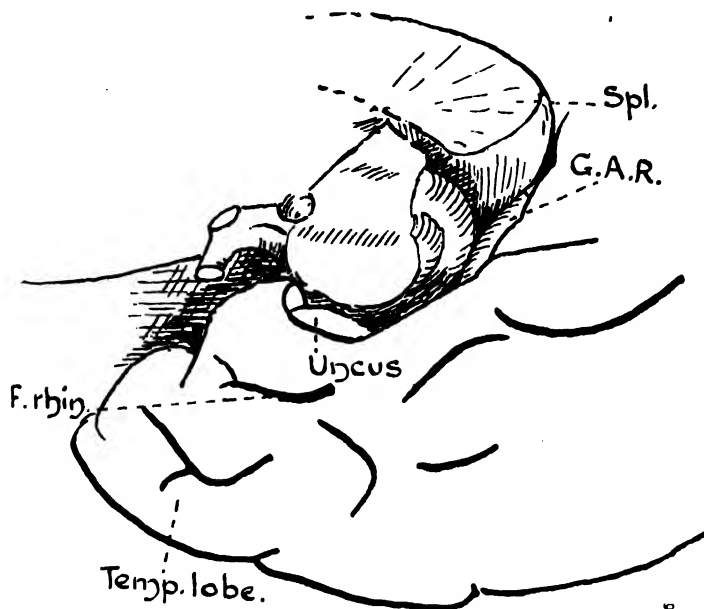
Fig. 256. Part of the mesial surface of the right cerebral hemisphere of a negro (No. 1). The Gyrus A. Retzii and the Uncus are shewn. The Fissura rhinalis (*F. rhin.*) is not unusually distinct as compared with the condition in the European brain. *Spl.* Splenium corporis callosi. *G.A.R.* Gyrus A. Retzii. *F. rhin.* Fissura rhinalis. *Temp. lobe.* Pole of the temporal lobe. (W.L.H.D. del.)

The brain of a young Zulu (cf. Fig. 258) bears a sulcus lunatus in each hemisphere. This brain is not described in detail, in the catalogue in which it is recorded[1]. The appearance of the occipital lobes is represented in the accompanying diagram (Fig. 258).

In addition to the foregoing observations, I have collected the following references to the literature of the negro brain, and append some notes upon the same.

[1] Elliott Smith, *Cat. Mus. Roy. Coll. Surg.* Vol. II.
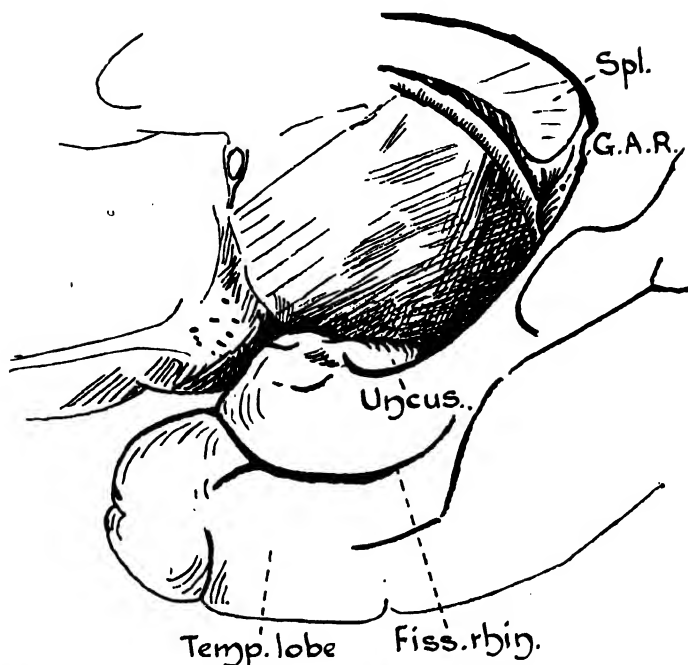
Fig. 257. Part of the mesial aspect of a negro brain (No. 2). The Fissura rhinalis (*Fiss. rhin.*) is very distinct.   *Spl.* Splenium corporis callosi.   *G.A.R.* Gyrus A. Retzii.   *Fiss. rhin.* Fissura rhinalis.   *Temp. lobe.* Pole of the temporal lobe. (W.L.H.D. del.)
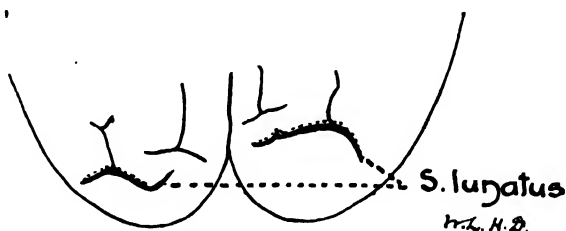
Fig. 258. The sulcus lunatus is shewn in each cerebral hemisphere of a young Zulu.   (*Mus. Roy. Coll. Surg.*)

Waldeyer[1] provides notes on twelve negro brains from German East Africa: the weights are recorded. Waldeyer points out that secondary convolutions are well developed; that the cuneus, pre-

[1] Waldeyer, *Sitz. d. k. Ak. d. Wiss*, Berlin, 1894 (Camb. Univ. Lib. Class 17-4-1, etc.). Many references given.

cuneus, and lobulus paracentralis present no distinctive features; that the "parieto-occipital sulcus" is extensive on the lateral cerebral surface, but no identification with the Affenspalte is attempted.   As a rare anomaly, the occurrence of the confluence of the sulcus olfactorius with the sulcus fronto-marginalis (Wernicke) is recorded.

Waldeyer's figures yield no sure information as to the presence or absence of the sulcus lunatus.

As regards the brain-weights: the average is 1148 gm. (the weights were recorded in the fresh state) for 12 brains.   Waldeyer quotes the figures of Topinard, 1234 gm. (range, 1445 gm. to 974 gm.) for 40 examples; and American records (War of Secession), as 1331 gm. for 121 cases.

Broca's work[1] does not give specific information as to the features of the rhinencephalon, or the occurrence of the sulcus lunatus or its representative.

Parker[2] represents (*op. cit.* Plate xxxvi.) the left hemisphere of the brain of a mulatto, with a sulcus lunatus (which seems to be described as the first occipital sulcus).   The same sulcus is seen in negro brains represented (Plates xli. and xlii.) in the same work.

Arkin[3] describes an Ashanti brain; the insula is submerged in this example.

Fallot[4] provides no very important data.

Calori[5] describes the brain of a negro from the Guinea coast. The sulcus lunatus is represented (but not recognised or specifically described) in each hemisphere: the fasciola grisea is very distinct in this brain: so is the gyrus subcallosus, and the rhinal fissure is deep, and boldly curved.

Hervé[6], in giving brief accounts of the convolution of Broca in seven brains of negroes, points out the comparative lack of

[1] Broca, *Memoir*, 1888 (Camb. Univ. Lib. i. 13. 17).

[2] Parker, *Journ. Ac. Nat. Sci.* Philadelphia (Camb. Univ. Lib. MA. 64. 10), also *Proc. Philad. Ac.* 1878 (Univ. Lib. MC. 16. 30).

[3] Arkin, *Neurologisches Centralblatt*, 1899, p. 741.   An abstract of the Russian memoir.

[4] Fallot, *L'Anthropologie*, 1890, p. 656.

[5] Čalori, *Mem. della. Ac. di Biol.* Ser. ii. Tom. v. 1865, p. 177.

[6] Hervé, *La circonvolution de Broca*, Paris, 1888.

tortuosity of this convolution, with the consequently rare appearance of three anterior limbs of the fissure of Sylvius.

White and Yellow races of Europe, Asia, and America.

(*a*)   The cerebral hemispheres of a Bengali native of India, and a Tamil, are thus characterised: in all four hemispheres the rhinal fissure presents no peculiarities and the central lobe is submerged: in three of the hemispheres a representative of the sulcus lunatus is seen, but in the fourth, the cortex has been locally destroyed in removing the brain (cf. Figs. 259, 260, and 261).   Reference must here be made to Kaes' work on a Hindu brain (*v. infra*, p. 440).
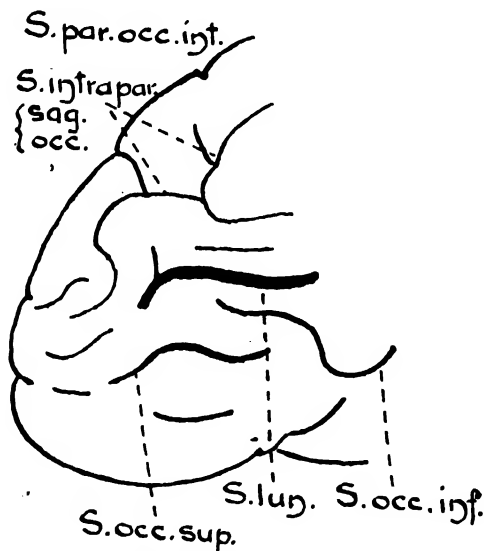
Fig. 259.   Right cerebral hemisphere of a Bengali.   The occipital convolutions are shewn.   (*Mus. Anat. Cant.*   W.L.H.D. del.)

(*b*)   Brains of Chinese: three brains are in the Cambridge Museum: two of these are of considerable size, the third being slightly below the average size of the European brain.   In four hemispheres the conformation of the rhinencephalon (so far as can be judged from macroscopic examination) does not differ from its appearance in the white races; in all six hemispheres the central lobe (insula) is submerged.   In five hemispheres, the sulcus lunatus
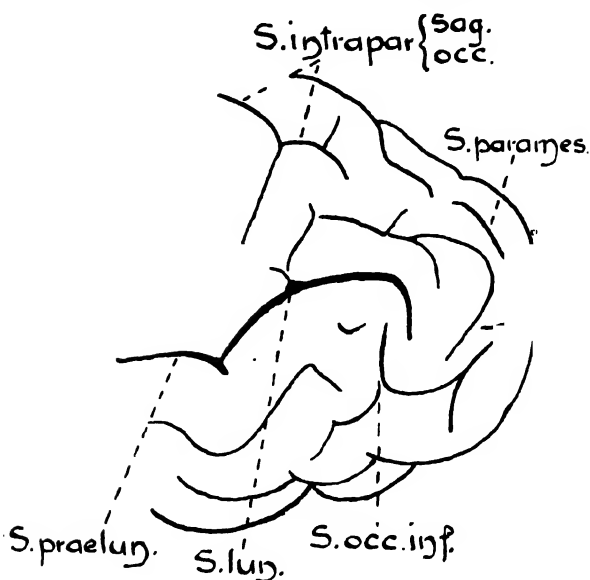
Fig. 260. Left cerebral hemisphere of a Bengali. The occipital convolutions are shewn. (*Mus. Anat. Cant.* W.L.H.D. del.)
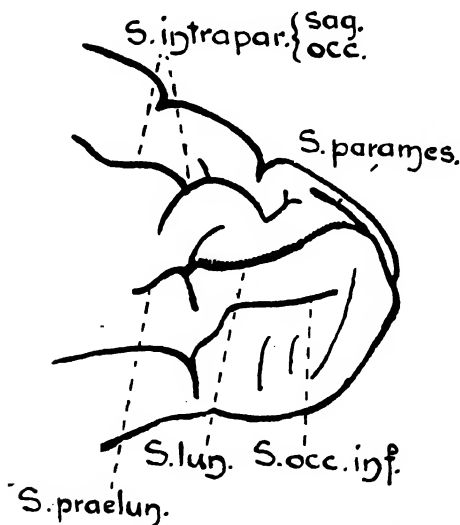
Fig. 261. Left cerebral hemisphere of a Tamil. The occipital convolutions are shewn. (*Mus. Anat. Cant.* W.L.H.D. del.)

was detected (cf. Fig. 262), though it was absent from the sixth hemisphere.
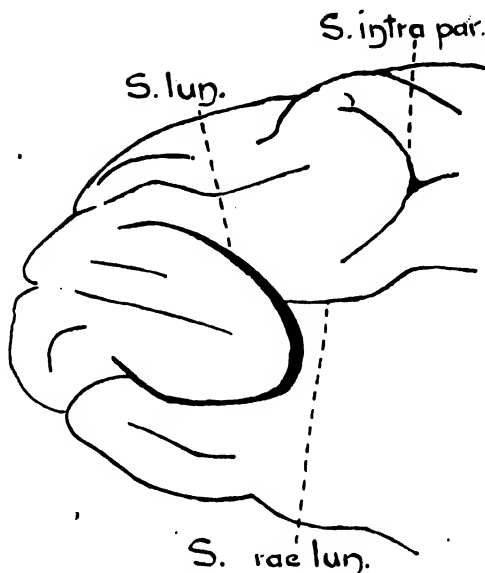
Fig. 262. Right cerebral hemisphere of a Chinaman from Singapore. The occipital convolutions are shewn. (*Mus. Anat. Cant.*   W.L.H.D. del.)

The ensuing notes refer to some of the existing literature on the Chinese brain.   Benedikt[1] has described three Chinese brains, but his illustrations are so indistinct that no certain information can be gathered from them, except that the cortex is richly convoluted.   In the illustration provided by Hatch[2], no definite sulcus lunatus can be detected.   Dercum's[3] paper is not accessible to me. Clapham[4] shewed that the average brain weight in sixteen Chinese exceeded the average brain weight in Europeans: in four Pelew Islanders, the brain weight on the average exceeded that of Europeans.   In Chinese and Pelew Islander brains alike, the convolutions were less tortuous than in brains of white races, and the Pelew brains are also characterised by the symmetry of the two hemispheres (a sinian feature).

[1] Benedikt, *Med. Jahrbuch. Neue Folge*, 1887, p. 121.

[2] Hatch, *Internat. Monatsschr. für An. und Phys.* 1891 (Band VIII.).   (Camb. Univ. Lib. I. 14. 8.)

[3] Dercum, *Journ. Nerv. & Ment. Dis.* 1889.

[4] Clapham, *Journ. Anthrop. Instit.* 1878.

Kaes[1] investigated the histology of the cortex in German, Hindu, and Chinese brains respectively. Variations in the relative amounts of the projection and association fibres were found, the former predominating in the Hindu, the latter in the German brain.

(c) Fuegians: Manouvrier[2] and Seitz[3] have described brains of Fuegians, the total number being three. In Manouvrier's example there seems to have been a sulcus lunatus in the left, but not in the right hemisphere. In none of the four hemispheres figured by Seitz is this sulcus recognisable. In complexity of convolutions, these brains are not markedly inferior to those of white men.

(d) The brain of a Laplander described by Retzius[4] presents no striking deviation from the brains of other Europeans.

(e) Among the white races, the brain has been specially studied among the Letts, by Weinberg[5].

(f) Two brains labelled "American races," are in the Paris Collection (*Mus. d'Hist. Nat.*); the left hemisphere of the larger specimen, bears an unusually distinct sulcus lunatus. Possibly the brain is that of the Fuegian described by Manouvrier (cf. Section (c) *supra*).

The Polynesian race.

The brain of a native of the Marquesas islands was examined by Manouvrier who reports[6] that the complexity of the cerebral convolutions was less than in the average brain of white men. The sulcus lunatus is very distinct in the left hemisphere of a Polynesian brain (a cast) at Paris (*Mus. d'Hist. Nat.*).

The Greenland or Eskimo race.

Six brains of Eskimo have been examined. The earliest data are provided by Chudzinski[7], then come the accounts given by Hrdlicka[8], and those published by Spitzka[9].

[1] Kaes, *Neurol. Centralblatt*, 1895, p. 889, also *Arch. für Psychiatrie*. Bd. xxv. p. 698.

[2] Manouvrier, *Bull. de la Soc. d'A. de Paris*, 1894, p. 895.

[3] Seitz, *Zeitsch. für Ethn.* Band xviii. (Camb. Univ. Lib. MH. 34. 44.)

[4] Retzius, *Virchow's Festschrift*. (Camb. Univ. Lib. ix. 9. 4.)

[5] Weinberg, *Das Gehirn der Letten*.   [6] *Bull. de la Soc. d'Anth. de Paris*, 1892.

[7] *Bull. de la Soc. d'A. de Paris*, 1881. (Camb. Univ. Lib. MC. 3. 52.) See also Hervé; *La circonvolution de Broca*, 1888.

[8] *Proc. Am. Med. Psych. Assn.* 1899. Also the *Am. Anthropologist* n. s. 3. 1901.

[9] *Amer. Journ. of Anat.* 1903. This paper contains a full bibliography.

Chudzinski pointed out the comparative simplicity of the convolutions of the cerebral hemispheres at his disposal, but the brain described by Hrdlicka does not indicate this as a general feature of the brains of Greenlanders.

Spitzka's material comprised two female and one male brain of Eskimo from Smith's Sound.   As regards the conformation of the basipallium and marginal pallium, and particularly the region of the uncus, incisura temporalis, and gyrus A. Retzii (balken-windung), Spitzka's figures yield no precise information.

Two brains were characterised by a degree of complexity of cortical convolutions in no way inferior to that found in white men. It must be admitted however, that the insula was in one of these specimens partially exposed.   In the third brain, the convolutions of the cerebrum were distinctly simpler than in the other two. The difference in the accounts of Chudzinski and Hrdlicka is thus explained, by the range of variation of the cerebral cortex. Spitzka suggests that the simplicity of the convolutions of the third specimen ("Avia") is explicable in view of the youth of the individual, a girl of twelve years of age.   But this explanation is not wholly satisfactory, for by that age the maximum weight[1], and probably the highest degree of cortical complexity has been attained in the white races.

As regards the sulcus lunatus, Spitzka's figures provide material for data relating to eight hemispheres, six of which are described by that author, the remaining two being those of the Eskimo brain described by Hrdlicka.   In two out of the eight hemispheres (viz. Fig. 5, op. cit. right hemisphere of "Atana" (♀), and Fig. 19, op. cit. left hemisphere of "Kishu," the Eskimo described by Hrdlicka) the sulcus lunatus can be identified.

Spitzka gives the average weight of the brain in three male Eskimo as 1457 gm, and in four females as 1228·7 gm, values in excess of the corresponding figures for European brains.

Bush race of S. Africa.

Gratiolet[2] figures the brain of the Bush-woman known as the Hottentot Venus.   In the illustration of this rather small brain no evidence as to the conformation of the rhinencephalon is forth-

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[1] Donaldson, *The Growth of the Brain*, 1895.

[2] *Mém. sur les plis cerebraux*, 1854.

coming, and attention must be confined to the neopallium; the cortical convolutions are infantile, not possessing the same degree of tortuosity as in adults of the white races, and they are not unlike those of some infants at birth. In the right hemisphere (*op. cit.* Pl. 2, fig. 2) will be seen a distinct vestige of the sulcus lunatus.
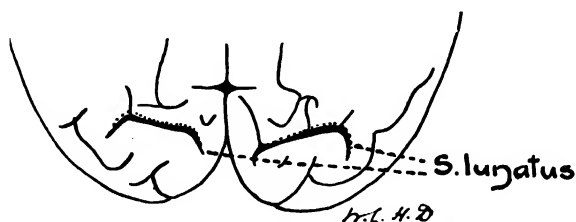
Fig. 263. The sulcus lunatus is shewn in each cerebral hemisphere of a Bush native. (*Mus. Roy. Coll. Surg.*)

Fig. 264. The sulcus lunatus is shewn in each cerebral hemisphere of a Bush native. (*Mus. Roy. Coll. Surg.*)

Two other brains of Bush natives were available for examination, viz. those in the Museum of the Royal College of Surgeons (cf. Figs 263 and 264). Of these one is a female brain (Nos. 706 and 707, *Cat. Mus. Roy. Coll. Surgeons*, Phys. Ser. Part 2), and as shewn in the accompanying sketch, the sulcus lunatus appears in each hemisphere. The convolutions in general are infantile in lacking the fulness of complexity usual in the white races. This brain was described in detail by Marshall (*Phil. Trans.* No. 154, 1864). The brain of the Bush-woman dissected by Flower and Murie (*J. A.* and *P.* Vol. I.) whose account furnished data for establishing many characters of the soft tissues in this type, was handed to Marshall for description. But no description appeared, nor does the brain appear to form part of the collection in the Royal

College of Surgeons. That collection does however possess the brain of a Bushman (No. 708) presented by Professor Marshall, and one is naturally led to suspect that there may be an error as to the sex, and that this is the brain of the woman dissected by Flower and Murie, a description of which is not forthcoming. However this may be, the specimen 708, whether male or female, is furnished with a sulcus lunatus in each hemisphere. Altogether then, the sulcus lunatus is seen in five hemispheres out of the six subjected to examination.

Rüdinger is quoted by Hervé, as giving an account of the brain of a Hottentot in his *Beitrag zur Anatomie des Sprach-Centrums*: p. 165. And Koch, quoted by Spitzka, described a Bush-woman's brain, in the *Archiv für Anthropologie*, Bd. III., p. 307. Wyman (*Boston Soc. Nat. Hist. Proc.* IX., p. 56) described a "Hottentot Brain" as weighing 3 lbs. 2 oz, which is not far removed from the average weight of the brain in the European races. No details of the conformation of this "Hottentot" brain are provided.

Before passing from this part of our subject, it remains to refer very briefly to certain conditions which occur anomalously in the brains of the Hominidae, and which claim attention and interest in view of the foregoing statements as to the constituents of the cerebrum.

We have seen that the basipallium or rhinencephalon is a prime constituent of the mammalian cerebrum, and indeed of the cerebrum in all vertebrates, save the very lowliest. Such conditions, therefore, as are associated with imperfect development, or with congenital absence of part or all of the rhinencephalon must therefore be of interest: and these cases constitute the first of the groups to which reference will be made.

We have also seen that the development of the corpus callosum is a grand characteristic of the neopallium of higher mammalia, and that the fulness of development of that commissure-system is distinctive of the Hominidae. What then, it will be asked, are the features of the human brain in which the corpus callosum is (from whatever cause, pathological or other) not developed? Cases of congenital absence of the corpus callosum constitute the second group to which reference will be made.

Thirdly, we saw that exuberant production of gyri on the neopallial surface was a second grand characteristic of the Hominidae as of the higher Eutheria in general. What then, will be the arrangement of gyri and sulci on the surface of a neopallium (of Man), in which the inherent growth-force has proved insufficient to reproduce the normal complex of surface-convolutions? Such instances make up the third group to which a glance must be directed.

A. Congenital defects of all or part of the Rhinencephalon.

The condition is well illustrated by a case of the congenital absence of the olfactory nerves in a human foetus (of about 8 months)[1] (cf. Figs. 265 and 266). The posterior part of the

Fig. 265.   Fig. 266.

Fig. 265. Right cerebral hemisphere of a human foetus; the olfactory nerves are not present, and in the proportions of the hemispheres, the cerebrum resembles that of Cetacea. (*Mus. Anat. Cant.*)

Fig. 266. Mesial aspect of the left cerebral hemisphere of the same brain as that represented in Fig. 265.

rhinencephalon is present, so are the corpus callosum and fornix. The neopallium is less fully convoluted than normally, the insula is exposed as in the Simiidae, and the form of the cerebral hemispheres is very remarkable, the vertical diameter being much

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[1] By a fortunate chance, I had the opportunity of submitting this remarkable specimen to Professors Retzius and Waldeyer, who agreed in at once remarking its unmistakably cetacean appearance.

increased, with concomitant lack of elongation antero-posteriorly. This gives a peculiar spherical appearance to the cerebrum, all the more noteworthy since this form is characteristic of the Cetacean cerebrum, in which, as is well-known, the olfactory nerves are normally absent, though, as in the above case, the posterior parts of the rhinencephalon can still be recognised.

B.   Congenital defect of the corpus callosum has been found in association with various other malformations.   Naturally the condition in which there is no subdivision of the cerebrum into hemispheres will first claim attention.   An example of such an anomaly of conformation is represented in Figs. 267 and 268, shewing two
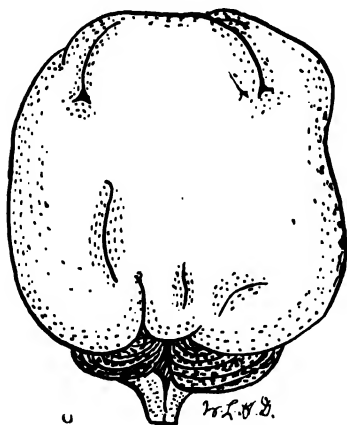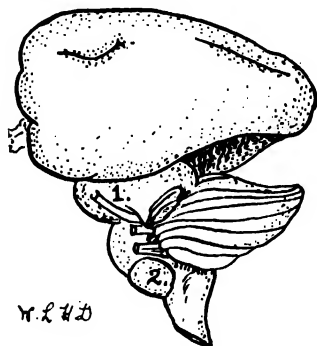
Fig. 267.   Fig. 268.

Fig. 267. The conjoined cerebral hemispheres of a Cyclopian human monster at the eighth month of foetal life. The upper aspect of the brain is shewn.

Fig. 268. Lateral view of the left aspect of the brain represented in Fig. 267. 1, Optic thalamus; 2, Olive.

aspects of a brain in which no division of the cerebrum exists. The specimen is the more interesting inasmuch as it was accompanied by apparent total absence of the rhinencephalon (for which reason it might have been cited in the preceding category), and the curious modification of the eyes and of the facial skeleton known as Cyclopia.

The chief features of this remarkable specimen are, the substitution of a single practically non-convoluted mass for the two

hemispheres; absence of the corpus callosum, of the fornix, and of the olfactory nerve; fusion of the two optic nerves into a single trunk.

It may be remarked that this is not an unusual conformation of the brain in cyclopian monsters, and further that the disturbance of development must have been experienced by the embryo at a very early stage, for the two cerebral vesicles are distinct at the commencement of the 5th week. (Cf. His. *Die erste Entwickelung des menschlichen Gehirns.* 1904, p. 6, Embryo KO.)

An instance of incomplete separation of the two hemispheres was recorded by Turner[1], and in this case the line of demarcation was a mere longitudinal groove. The corpus callosum had failed to appear, and there was but one ventricular cavity. The brain was removed from an adult and convolutions were present, though their arrangement was indistinct.

A good example of deficiency of the corpus callosum uncomplicated by lack of distinction between the two cerebral hemispheres, is recorded by Forel and Onufrowicz[2]. The brain was that of an adult (cf. Fig. 269) and no part of the corpus callosum can be seen. Not only so, but the fornix-commissure (the psalterium, or original dorsal commissure) is equally undeveloped. On the other hand the anterior commissure, the fascia dentata, the fimbria, the

Fig. 269. Mesial aspect of a human cerebral hemisphere in which the corpus callosum was not developed (after Forel). The indications are as follows:
Ca : Anterior commissure.
Ot : Optic thalamus.
Gy. hipp: Gyrus hippocampi.
Lt. Lamina terminalis.
CS. Calcarine sulcus.

body of the fornix, the uncus, and the gyrus A. Retzii are all present[3].

With regard to the neopallium, the chief point to notice is

[1] *J. A. and P.* Vol. xii. 1878.
[2] *Tageblatt der Versammlung Deutscher Naturforscher in Salzburg*, 1881.
[3] *Archiv für Psychiatrie*, 1887.

the "radial" disposition of the neopallial sulci, which appear to radiate from the optic thalamus (on the mesial aspect), or the insula (on the lateral aspect). This point however has now but an historical value. Before the true nature of the so-called transitory fissures was known, their radial disposition was considered to be connected with the non-development of the corpus callosum, which had not yet appeared in those early embryonic brains: and this surmise was strengthened by the observation (just quoted) of the radiation of sulci, in brains of which the corpus callosum has not subsequently been developed.

The absence of a definite gyrus fornicatus is noteworthy: nor does the sulcus lunatus appear to be present. Forel and Onufrowicz have collected records of no less than twenty-seven instances of brains lacking the corpus callosum more or less completely. In some of these cases the brain was microcephalous, presenting features which will be referred to in the sequel. In some instances not only was the corpus callosum absent, but the fornix with the psalterium, the septum lucidum, and even the anterior commissure, might be undeveloped, as we have seen occurred in the cyclopian brain just described.

Professor Elliott Smith has kindly put at my disposal photographs of two brains of native Egyptian Fellaheen women, in which the corpus callosum is quite rudimentary. But in both brains, the neopallium is normal in amount and appearance. Exceptions thus occur to the general statement (made on p. 398) viz. that the size of the corpus callosum bears a direct relation to the mass of the neopallium. And since, as remarked, the neopallium in these Egyptian brains is not less massive than usual, the disposition of those fibres which would normally cross in the corpus callosum, but which do not do so here, must remain enigmatical.

C. The last group to be considered comprises examples of the pathological condition known as Microcephalus. In these cases of idiocy, the growth of the brain is arrested prematurely; the neopallium and its convolutions are involved in this condition; and as a result, the growth of the cranium is aborted. The cranial form accompanying Microcephalus is thus quite peculiar, since the facial parts may attain full development while the cranium
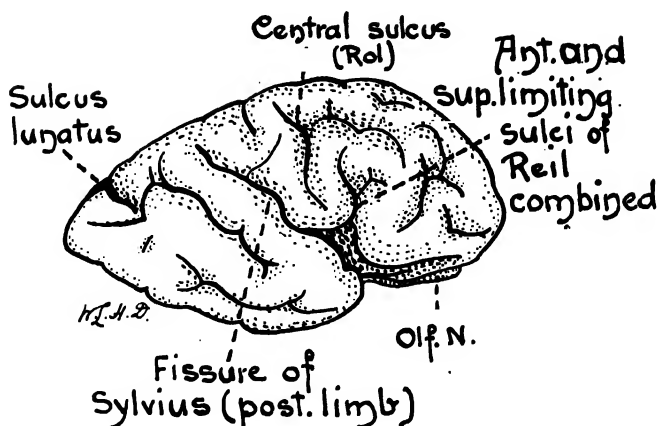
Fig. 270. The right cerebral hemisphere of a microcephalic idiot girl (Bertha Roemer). This brain shews a remarkable similarity to those of the Simiidae (cf. Fig. 271). The specimen is in the Anatomical Museum at Halle and, though referred to by Giacomini (*I Cervelli dei Microcefali*) as very remarkable, has never been described in detail.
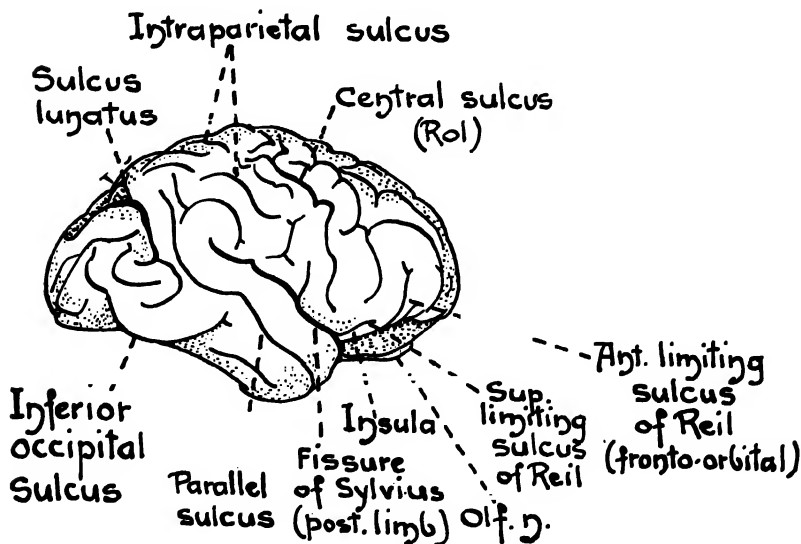
Fig. 271. The right cerebral hemisphere of an anthropoid ape (a Gorilla) for comparison with the cerebral hemisphere of the microcephalic human being. (*Mus. Anat. Cant.* W. L. H. D. del.)

is disproportionately small. Without entering into further dis-
cussion of the relations of brain-growth and skull-growth, nor
even considering the possibility of discriminating between micro-
cephalous individuals, with a view to separating purely pathological
cases from such as may justifiably be relegated to the category
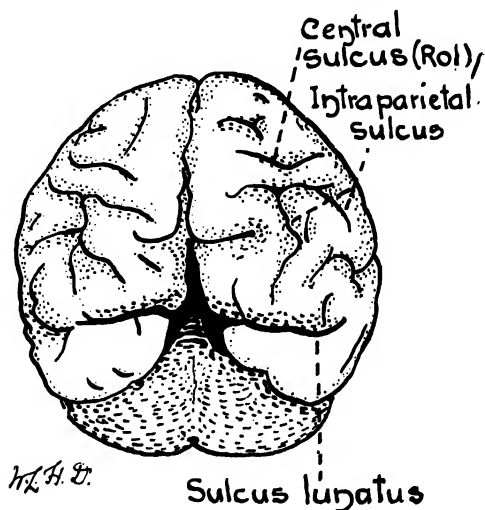
Fig. 272.   The microcephalic human brain represented in Fig. 270, here viewed
from above.
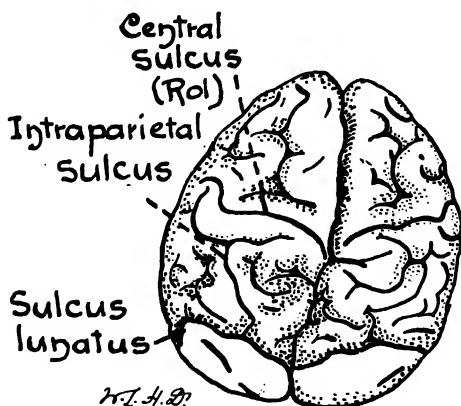
Fig. 273.   Brain of a Gorilla (*Mus. Anat. Cant.* "H"), as seen from above: for
comparison with the microcephalic human brain shewn in Fig. 272.

of veritable atavistic productions, it must be repeated that the result, so far as the encephalon is concerned, affects principally the neopallium; incidentally, the rhinencephalon may be thrown into undue prominence, but the chief distinction between the microcephalic and the normal cerebrum lies in the cortex, and particularly, as has been said, in the neopallial folds. These are found to have been arrested in growth, and may correspond in their permanent arrangement to the stage normally reached by the foetus at any time from the commencement of the fifth month of existence; nor should the parallel be drawn with these brains only, but also (and with even more striking results) with those of the Simiidae, while resemblances of detail may be traced to lower and even non-primate forms such as the Ursidae (Carnivora). The accompanying figures (270, 271, 272, 273) bear out the foregoing remark as to the close similarity between the microcephalous cerebrum and those of the Simiidae, and attention is specially directed to the incompleteness of the frontal operculum of the insula, and to the well-developed sulcus lunatus exhibited by the specimen shewn[1].

IV. **Palaeontology.** The amount of available material for the study of the encephalon from the standpoint of Palaeontology is necessarily very scanty in amount. For owing to the perishable nature of the tissues, we are confined to inferences drawn from the features of the skull in which the encephalon was contained. From these, we can infer little or nothing regarding parts of the encephalon other than the cerebrum, if we except surmises of a general character as to the proportionate bulk of the cerebrum and cerebellum.

Casts[2] of the endocranial cavity are most conveniently employed for these studies: and they will also provide information as to the proportionate length and breadth of the cerebrum.

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[1] Cf. Giacomini, *I cervelli dei Microcephali*; also Cunningham and Telford, *The brain of the Microcephalic idiot*. But the subject has now a very extensive literature, which could not well be recorded in this place.

[2] The best work on the brain-casts of the Primates in general, is that of Elliott Smith. *Cat. Mus. Roy. Coll. Surgeons.*

Beyond this, the evidence is indirect, and indeed, as regards the Hominidae, the existing members of the Primates provide so complete a series of examples demonstrating the evolution of the specially human features of the cerebrum, that in one instance only can the study of fossil forms be expected to throw light on this part of the subject.

That instance is the fossil Primate-form known as Pithecanthropus erectus, the characters of which are more fully discussed in Chapter XVII. In the present connection it will suffice to mention, that the characters of the cerebral hemispheres of Pithecanthropus erectus have been ascertained with fair accuracy from the impressions on a cast of the interior of the skull-cap; and that moreover, both in respect of relative bulk and of the conformation of the neopallial convolutions, the encephalon of Pithecanthropus supplies confirmatory evidence as to the position claimed for it, viz., intermediate between the families Simiidae and Hominidae[1].

The endocranial cast of the Neanderthal cranium bears the remarkable button-like protrusion of the occipital end of the left cerebral hemisphere which is described by Elliott Smith as constantly associated with a well marked sulcus lunatus.

Elliott Smith has examined several specimens of desiccated brains of very ancient inhabitants of Egypt. These brains still shew traces of the gyri and sulci, which differ in no important respects from those of modern Hominidae[2]. A similarly preserved, but much less perfect brain was found in the cranium of an ancient (Mound-builder period) inhabitant of Ohio[3]. No details of its structure are on record.

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[1] Cf. Dubois. Internat. Congress of Zoology. Cambridge 1898. It is noteworthy incidentally, that Dubois in the above communication lays much stress upon the relatively large size of the third or inferior frontal convolution as shewn in the brain-cast of Pithecanthropus erectus. This cannot however be claimed as a human feature, for Cunningham has pointed out that the relatively large inferior frontal convolution characterises the Simiidae rather than the Hominidae.

[2] Elliott Smith, *J. A. and P.* Vol. xxxvi. p. 375.

[3] Woodhull, *Z. für Ethn.* Band 33.

CHAPTER XVI.

THE MORPHOLOGICAL VARIETIES OF THE HOMINIDAE.

HAVING thus completed the description of the methods of investigation, it is now time to turn to the results of research in the field of comparative human morphology; and in the first instance it will be well to consider the morphological types of the human skull; while secondly, we shall find some evidence, to shew that by taking cranial morphology as the first criterion, and adding criteria derived from other parts of the skeletal system, as well as from other anatomical systems, a classification of human races may be based upon these morphological foundations.

In no department of Physical Anthropology is more literature available than in the field of comparative craniology[1].

That the differences in form are immense, is immediately apparent on an even cursory inspection of any large collection of human crania, and especially if these are of European provenance. Without dwelling further upon the difficulties of classification, we must approach the subject more nearly, and, from an examination of the actual specimens, draw such conclusions as may be applicable to the problem before us.

In the first place, we have to eliminate the variations dependent on age and sex, and consequently our first task will be to re-consider the characteristics of immature crania. In a preceding chapter much attention was paid to the characters of the human foetal cranium at the termination of intra-uterine life: it will therefore be unnecessary to re-open this side of the

[1] Moreover this side of the subject has been popularised, and presented in a distorted form to the public, in the guise of Phrenology, which has impressed on its devotees a false idea of the fixity of cranial form in the several human races.

question. But a few words may be added in description of the more salient features of the skulls of children, and in this connection special reference must be made to Merkel's researches on growth changes in the skull from infancy to maturity.

Turning from the descriptive side of craniology to the results of measurements and the consequent determination of indices, we may notice that the infantile cranium tends on the whole to brachycephaly, though actually during parturition, pressure may temporarily produce elongation and even extreme dolicho-cephaly (exceptions to this statement must be made in the case of what is termed unreduced occipito-posterior or vertex presenta-tions)[1]. The alveolar index is represented by figures denoting less prognathism than in adults (in spite of Merkel's statements), and the nasal aperture is very wide in proportion to its height: the face is narrow (leptoprosopic), and the zygomatic arches invisible in the vertex view of the cranium (crypto-zygous). The orbits are megaseme; and the weight of the skull is small, in proportion to the figure representing its capacity (cranio-cerebral index).

In the next place, the senile type of cranium falls under consideration here. As in the infant so in the aged skull, the facial skeleton is reduced; but essential differences obtain: in the infant the maxillary antrum is undeveloped, the teeth have not yet made their way to the surface, and in the mandible the alveolar component is predominant. In the senile skull, and with the loss of the teeth, the alveolar parts of the maxilla and mandible tend to recede and disappear by absorption, and of the mandible there may remain practically little more than the body. In infant and octogenarian alike, the mandibular angle is more widely open than in the intervening stages. The second remarkable feature in senile crania is the closure of sutures by synostosis: this closure, which is in progress throughout life, may in aged persons become practically universal. Finally the skull as a whole tends to become somewhat lighter, in consequence of absorption of the tissues; and though instances of senile thickening are not un-common, they are not certainly free from the suspicion of owning a pathological origin.

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[1] Cf. Budin, *Traité des accouchements.*

In the third place, the sexual differences obtaining in crania are to be noted. From the descriptive point of view the female skull presents the following characters. The skull as a whole is slighter, less massive and of smoother surface than that of the male: with respect to the cranial part, a striking feature is the lack of prominences, whether such as the supra-orbital ridges connected with air-spaces, or such as the temporal ridges, nuchal lines, and mastoid processes, associated with muscular attachments. The temporal ridges are farther removed from the sagittal suture than in the male skull. The sagittal contour of the cranial vault is frequently flattened near the bregma, the character when exaggerated giving rise to the appearance described as clinocephalic. The frontal bone rises more vertically and abruptly than in male crania.

The characters of the supraorbital ridges have already been mentioned. The orbital margins are finer and generally possess a sharp edge. The zygomatic arches are more slender than in male crania; the maxillae and teeth, and indeed the whole facial skeleton, are smaller than in male crania. The occipital condyles are narrower. Manouvrier has pointed out that, in many of the foregoing respects, the female skull shares with the infantile skull, a position indicative of higher morphological development and specialisation than that attained by the male.

When the craniometrical side is studied, we are surprised to find a slightly greater degree of prognathism, which is explained by the projection of the lower part of the face, especially the alveolar margin of the maxillae; this subnasal projection more than compensates for the otherwise small proportions of the facial skeleton. The latter is to be designated leptoprosopic, from observations on the facial index: and the stephano-zygomatic index provides a higher figure than for male crania. In consequence of the greater vertical orbital height and the associated lack of prominence of the supraorbital ridges, the orbital index provides a higher figure, i.e. is more megaseme, in the female skull. Lastly, the cubical contents are less than in the male, the factor of absolute bulk being naturally influential in this respect.

Such then are the more prominent characteristics of the feminine cranial type: but it must be remarked that there are

many instances in which it is not possible to assign with certainty a skull to one or the other sex. This uncertainty is more generally due to the male cranium tending to assume feminine characters than the converse, and such ambiguity seems more frequent among members of the most highly civilised communities. But the negro races offer a very curious study in this respect: for though among the Oceanic negroes there are found some of the most striking contrasts due to the development in each sex of cranial characteristics peculiar to it[1], yet in the case of many African negro tribes, the sexual cranial differences are as completely veiled as in any examples that can be adduced.

The ground having thus been cleared by eliminating the special cases of immature, senile, and female cranial characters, we are now in a position to undertake the study of a large collection of human crania gathered from all parts of the world.

To attempt to reduce the innumerable forms to some natural order, we must select from the list of characters and indices a certain number, remembering that unsatisfactory results are just as likely to accrue if we demand too many qualifications, as when too few tests are employed. Description from inspection, measurement, and calculation of indices from the data thus provided, are the first steps in the investigation. And as a result, variety and diversity of conformation will be found to obtain in respect of any character we may select. For the purpose of explaining the results, let us select the breadth index as an example. Judged by this test, we find crania varying in proportions from the very narrow to the extremely broad. But when we add other tests, we do not find that very narrow or very broad crania are always associated with great prognathism, or small capacity, and thus we are arrested in our endeavour to place one above the other, in what we have called the natural order or series which we desire to discover.

Leaving for the moment the respective claims of skulls of each form, whether long, or short, to be considered the more highly evolved, the following aspect of the subject is submitted as likely to lead to practically useful results. Support is claimed

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[1] Excellent examples may be seen among crania from New Britain in the Anatomy School, Cambridge.

for the view that primitively neither dolichocephalic nor brachy-cephalic tendencies were so intense as they have subsequently become: it is submitted as highly probable, that primitively the cranium was in a comparatively undifferentiated state, though possessed of latent powers of specialisation, just as a primitive morphological animal form may be undifferentiated as compared with its specialised descendants.

Such a point of view may be termed monogenist, but it is to be most clearly distinguished from the totally different monogenistic views which were the arena of such controversial displays in the history of anthropological study in the XIXth century. Here we simply postulate the existence of a common stock of humanity, not clearly differentiated into groups by their skulls. The examination of large collections of human crania leads one to favour such a view. It must be reserved for wide investigations to prove or disprove its correctness, and we must not overlook the fact that evidence may be brought against it[1]. But for the moment, and apart from such considerations, the assumption of the former existence of such an undifferentiated skull-form is of very great use in illustrating the systematic relations of existing cranial types. For the primitive stock may be compared to a sheet of water, the margins of which accommodate themselves to the shores, and just as the periphery of a lake or inland sea may be marked by rounded bays or narrow fiords, so the original skull-group has thrown out offshoots, some to a smaller, others to a greater distance from the parent stock, the distance traversed representing the degree of specialisation undergone. An even better simile, perhaps, is that of an amoeba or some such amoeboid protoplasmic mass as is seen in that lowly form of plant-life, Aethelium septicum (a fungus of the Myxomyces group). In these organisms pseudopodia are protruded, some bud-like and apparently truncated, others elongate and slender, not only in two, but in three dimensions of space. So we may imagine the specialised long and short cranial types to represent offshoots from the generalised stock, which is continually by trial and experiment adapting itself to its changing environment.

[1] Cf. Karl Pearson, *Phil. Trans. Roy. Soc.*

For further illustration, we may select three cranial characters; variable, so that we may distinguish sub-groups or types by the mode in which they are presented to us by a collection of crania. And the reason for the limitation to three, will easily be understood from the preceding reference to the dimensions of space.   After considering the effect of applying a threefold qualification, we may proceed to discuss the results obtained when a greater number of criteria are combined.   The tests then that we shall select are (1) the proportion of cranial breadth to length as illustrated by the Breadth Index: (2) the degree of Prognathism: (3) the cranial Capacity, as evidenced by the figure representing the cubical contents, or by the cranio-cerebral index.

We may now treat of the first two of these characters, and survey the results in Fig. 274, which has been constructed in the following way. Two axial lines cross each other at right angles. Considering first the horizontal line, we premise that examples above it tend towards dolichocephalic cranial proportions, while those below are comparatively brachycephalic. With regard to the vertical, axis, the right side corresponds to prognathism, increasing with the distance from the axis; and the left side is set apart for orthognathic examples. The results have been worked out approximately to scale on "quadrille" paper, but a qualitative demonstration will suffice for the moment. The diagram shews us an irregular figure consisting of a central mass from which

Fig. 274. Diagram to represent the relations of several human racial types as indicated by their cranial features. Figures in the vertical column represent values of the cephalic index, those in the horizontal line being values of the prosthionic (or alveolar) index.

project processes (pseudopodia): translating these into craniological

terms, each corresponds to a specialised skull-type, which has become to a certain extent (varying from type to type) separated from the main mass of indefinite forms, whence such varieties arise in response to the influence of certain agencies, whether natural, sexual, or other selection. The distance by which any type-form is thus separated, is indicated by the length of its pedicle, and this gives an indication of the uniformity of that type, and of its constancy in its own particular territory. Yet no type is isolated: each has a pedicle or stem, for the most extreme cranial form is linked to the generalised type by a chain of intermediate examples so numerous as to make the transition an imperceptible one[1]. The diagram thus indicates that certain types of skull may be clearly differentiated from the mass, and moreover that specialisation has been directed along the lines (as denoted in the choice of the criteria) of proportionate breadth or narrowness in the first place, and of greater or less projection of the jaws in the second. We thus see four groups of crania, indicated by the position of the "pseudopodia" relatively to the two axes that have been drawn, and we distinguish the classes according to these positions as

      1. Dolichocephalic prognathous,

      2. Brachycephalic prognathous,

      3. Brachycephalic orthognathous,

and 4. Dolichocephalic orthognathous groups.

We now proceed to consider these in detail, taking them in any order, but conveniently we may follow that of the clock-hand. We notice two long processes marked I and II in the dolichocephalic, prognathous class, differing both in dolichocephalic and prognathic characters to some degree, the former being more dolichocephalic, the latter more prognathous. The second quadrant contains two processes likewise, but these are not considered sufficiently divergent to necessitate numerical distinction and will be bracketed as III (brachycephalic and prognathous crania). In the next quadrant we find one irregular process, to which the number IV is applied, and with it a closely associated process runs across the boundary into the fourth quadrant. Skulls of group IV are mainly brachycephalic and orthognathous, but the transition

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[1] With this figure may be compared the suggestive diagrams published by Petrie and by Thomson. Cf. *Man*, 1902, Nos. 61, 95, 118.

is very easy to the dolichocephalic orthognathous group, from which two pesudopodia project near the dividing line, between ortho- and prognathous crania, while a third is more nearly approximate to the dolichocephalic prognathous group. The last-mentioned groups are numbered V, VI, and VII respectively. It remains to trace their relations when the third criterion, viz. of cranial capacity, is added, To see these, we must draw a second diagram (cf. Fig. 275), which represents our model of the hypothetical skull-forms (as shewn in Fig. 274) viewed from the side, in such a way that what is uppermost in Fig. 274, is to the right hand in Fig. 275. The latter figure is in reality simpler in
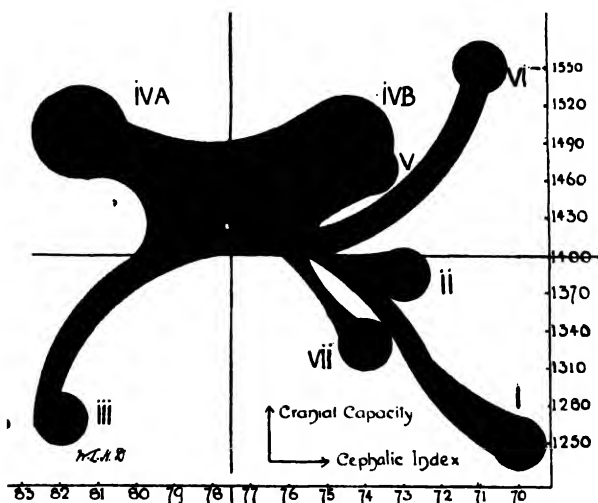
Fig. 275. Diagram to represent the relations of several human racial types, as indicated by their cranial features. The figures in the vertical column represent values of the cranial capacity, those in the horizontal line being values of the cephalic index.

construction than Fig. 274, for account is taken of one new character only, and so we have in the first place a horizontal axis: values of megacephalic skull capacity (cf. the classification by the cranial capacity) place examples above, while microcephalic values place examples below, the axis. The vertical axis is drawn in a vertical plane through the axis xy of Fig. 274.

Fig. 275 shews us that we must distinguish among the

groups I—VII provided by Fig. 274, those of lesser from of greater capacity. For we see that, again proceeding as be:

Groups IV B, V, VI are of great capacity (and dolichoce and orthognathous, *v.* Fig. 274).

Groups I, II, are of small capacity (and dolichocephalic prognathous, *v.* Fig. 274).

Group III is of small capacity (and brachycephalic prognathous, *v.* Fig. 274).

Group IV A is of great capacity (and brachycephalic and orthognathous, *v.* Fig. 274).

Group VII is of small capacity (and also dolichocephalic and orthognathous, *v.* Fig. 274), and when this list is revised so as to bring the groups into their numerical order, it is seen that:

Group I consists of skulls which are dolichocephalic, prognathous and of small capacity.

Group II consists of skulls which are dolichocephalic (less so than Group I), prognathous (more so than Group I), and of small capacity (but not so small as Group I).

Group III consists of skulls which are brachycephalic, prognathous, and of small capacity.

Group IV consist of skulls which may be either dolicho- or brachycephalic, which are orthognathous and of large capacity.

Group V consists of skulls which are dolichocephalic (more so than the dolichocephalic members of Group IV), orthognathous and of large capacity.

Group VI consists of skulls which are dolichocephalic (more so than either Group V or the dolichocephalic contingent of Group IV), orthognathous and of great capacity (exceeding both Groups IV and V).

Group VII consists of skulls which are dolichocephalic, orthognathous, and of small capacity.

We have thus become cognisant of seven groups of crania, which may be considered as representing terminal forms, when judged by their morphological conformation. It must no: forgotten however, that laboured as the foregoing explanation is yet incomplete, because three characters only have been sele this is admittedly a small number, but with an increase in number of criteria, much complexity in setting forth the

would have ensued.   Further it is to be noticed, that only the
extremely long "pseudopodial" processes have been selected as
groups: the diagrams 274 and 275 would be more accurate if
innumerable bud-like processes were made to jut out round the
whole periphery of the central mass, so as to represent the less
clearly differentiated skull-forms of types, as well as those comprised
in the above list.

Again, the diagram shewn in Fig. 274, is "centred" on the
intersection of two lines, one of which is horizontal and corre-
sponds to the numerical value 77·5 for the breadth-index, the
other (vertical) line corresponding to an alveolar index of 100·5.
But in an earlier period in the history of the Hominidae the
centre might well have been determined by other lines, such for
instance as would reveal the mean human type as more dolicho-
cephalic and more prognathous than at present.

Actually however, the foregoing method and classification is at
least a working one, and we find that when we impose other tests
and criteria, the relative positions and prominence of the several
groups are not very sensibly altered.   We shall therefore proceed
to add to each group some other characteristics which will serve for
its further differentiation from the rest; and it will also be possible
to assign to each a certain number of specific characters, drawn
from other morphological systems, clear evidence that we are here
at least on the track of, if we have not actually attained, that
natural system, of which we have been in search.   And since some
nomenclature is almost a matter of necessity in addition to
numeration, the geographical distribution (rather than so-called
racial nomenclature) may be used as further defining the several
groups, which we may now call types.   The synonymy then works
out in the following manner.

Group I.   Australian.
Group II.   African (negro).
Group III.   Andamanese.
Group IV.   Eurasiatic.
Group V.   Polynesian.
Group VI.   Greenland.
Group VII.   South African.

From what has already been said, it follows that in t'
geographical areas, the environment tends to the perpetua:
of the particular cranial form associated with the name in
list. But that, although the predominant cranial form
this kind, other forms are not necessarily excluded from spo:
occurrence, and in fact the type-form of one area may
closely imitated by an occasional sporadically-occurring anomalous
form in a second area. Thus, for instance, is explained the
occasional appearance in European collections of anomalous cranial
forms undoubtedly of European provenance, which nevertheless
closely resemble the form of cranium normal among African
negroes.

Thus are explained the occurrence in Egypt, of Soudanese
skulls closely resembling those of aborigines of Australia, or
of crania resembling those of the South African group (unless
indeed in the latter case there has been an unsuspected north-
ward extension of the latter group in bygone ages[1]).

We must further note that two groups or types, viz. Nos. III
and VII, are associated with pygmy stature: other pygmy races
exist, but the cranial characters of these enable them to be brought
into line with one or other of the existing groups, including of
course Nos. III and VII themselves[2].

Finally we may remark that of the seven specialised forms
distinguished in the foregoing list, the first presents the greatest
number of simian characteristics combined in one type, and the

[1] It is because the Hominidae are so capable of overcoming the geographical
barriers which impose such definite limits upon the extension of many animals, that
the study of the geographical distribution of racial types is constantly diminishing
in importance and value.

[2] Since drawing up the foregoing scheme of the relations of human racial types,
I have seen the diagram prepared by Stratz in illustration of a memoir upon this
subject published in the *Archiv für Anthropologie* (1900).   The author therein
groups the several human types around the aborigines of Australia taken as a central
unit, and as a prototype; and the colour of the skin is used in the first instance as
a criterion. To me this scheme appears unsatisfactory, for there is no little evidence
to the effect that the aborigines of Australia are in certain respects highly specialised
representatives of the Hominidae. Such "centralisation" of the aborigines of
Australia is a view much favoured at present by certain writers, especially per[
Schoetensack, cf. *Zeitschrift für Ethnologie*, Band 33, and Klaatsch, cf. *Anatom*[
Hefte, 1902, but it is not appropriate to enter upon its detailed discussion
cf. Chapter xviii.

same remark applies to other morphological characters associated with this form of skull. The second group comes next in this order, after which the evidence upon which the groups can be co-ordinated becomes vague and indefinite, so that their morphology as at present known will not alone suffice to reduce all the known varieties of Man to an order representing their respective grades of evolution. This conclusion points to the necessity for extended research, directed to every anatomical system in the several groups submitted to the investigation.

The characters of the several Groups will now be enumerated in order.

Group No. I.

Synonym. Australian.

Distribution. Australia with Tasmania, Melanesia, New Guinea : sporadically throughout Oceania, and also in Africa.

Indices of skull. (*Average value in males.*) Cf. Figs. 276, 284, 292.   Breadth 70·95. . Alveolar 101·1. Nasal 55·1. Height 71·0. (In the hypsi-steno-cephalic variety (common in Melanesia) this index has a somewhat greater numerical value.)

Figs. 276—283 incl. Representative cranial types I—VII (corresponding to the seven Groups described in the text) seen in norma verticalis : the figures are reduced so that the maximum cranial length is uniform throughout the series. (*Mus. Anat. Cant.* W.H.L.D. del.)
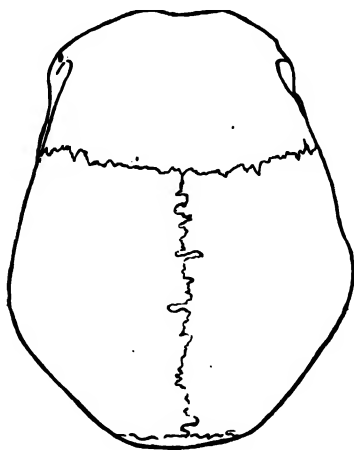
Fig. 276. Type I. Australian.   Fig. 277. Type II. African.
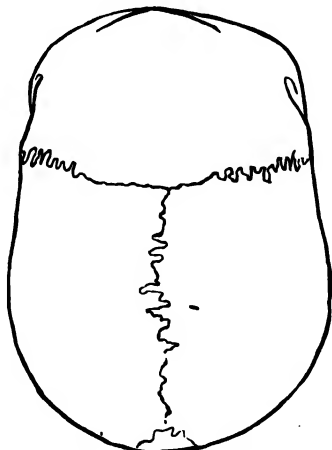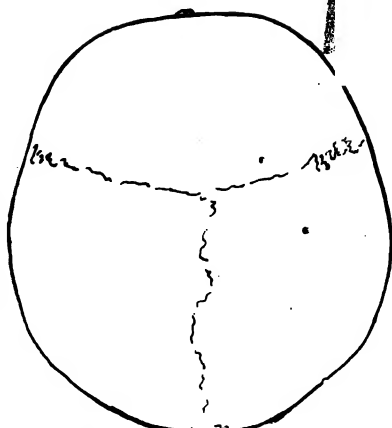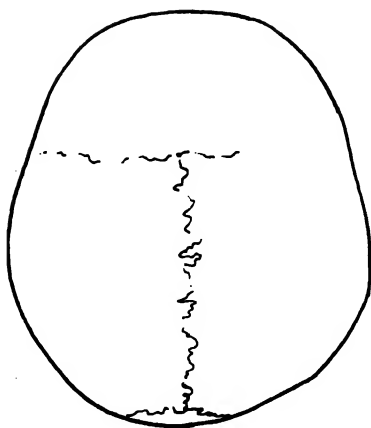
Fig. 278. Type III. Andamanese.   Fig. 279. Type IV. Eurasiatic, subdivision A.
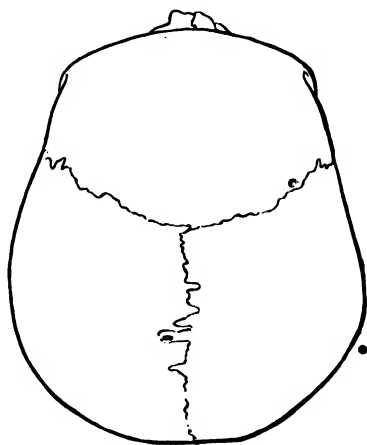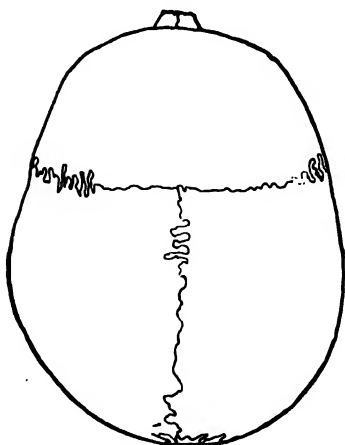
Fig. 280. Type IV. Eurasiatic, sub-division B.   Fig. 281. Type V. Polynes
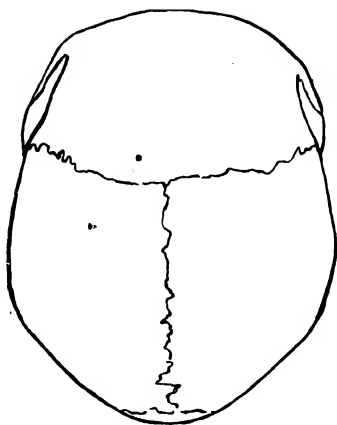
Fig. 282.   Type VI.   Eskimo.   Fig. 283.   Type VII.   South African.
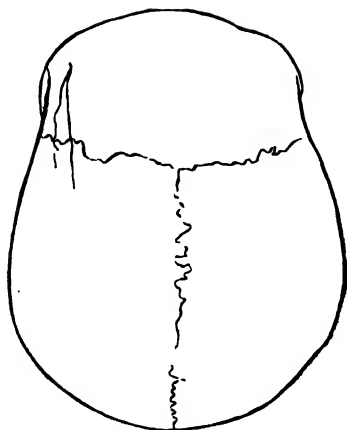
Figs. 284—291 incl. Representative cranial types I—VII. seen in norma lateralis; the figures are reduced so that the basi-nasal length is uniform throughout the series.   The extraordinary range of variety in this dimension is expressed by the difference in size of the drawings when the latter are thus proportionately reduced. (*Mus. Anat. Cant.*   W.L.H.D. del.)
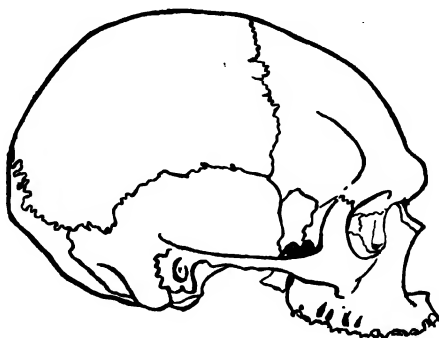
Fig. 284.   Type I.   Australian.
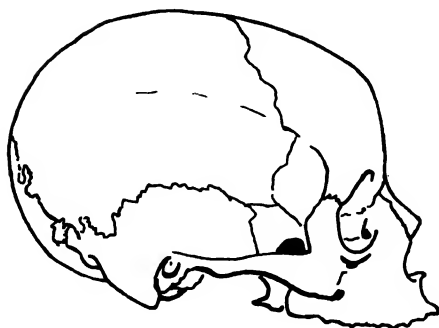
Fig. 285.   Type II.   African.
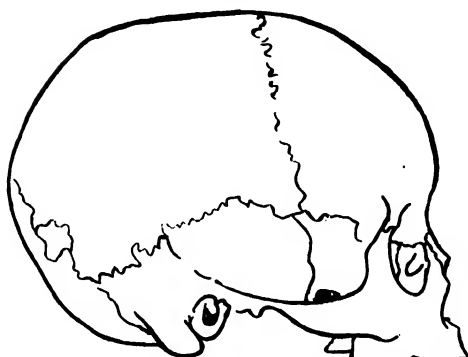
Fig. 286.   Type III.   Andamanese.
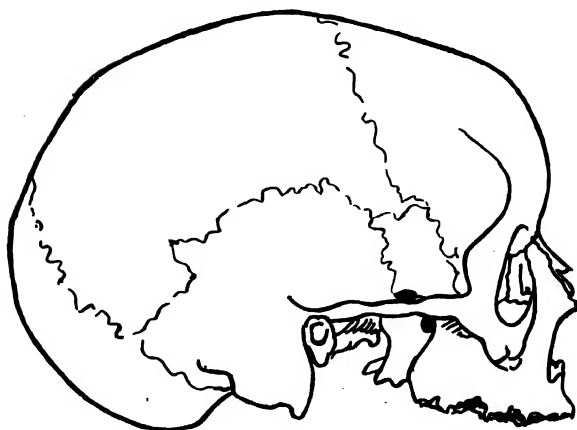
Fig. 287.   Type IV.   Eurasiatic, sub-divison A.
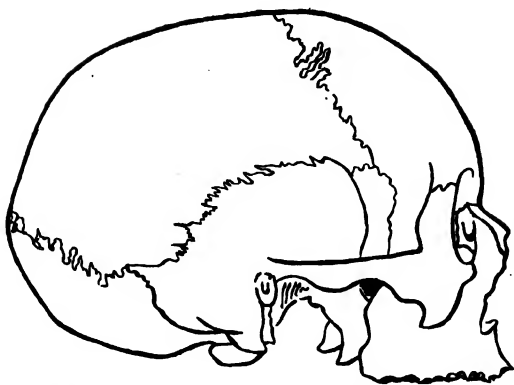
Fig. 288.   Type IV.   Eurasiatic, sub-division B.
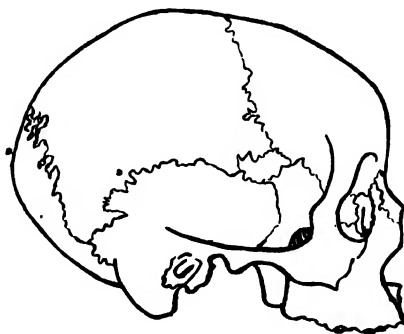
Fig. 289.   Type V.   Polynesian.

Fig. 290.   Type VI.   Eskimo.

Fig. 291.   Type VII.   South African.

Figs. 292—299 incl.   Representative cranial types I—VII. seen in norma facialis.   (*Mus. Anat. Cant.*   W.L.H.D. del.)
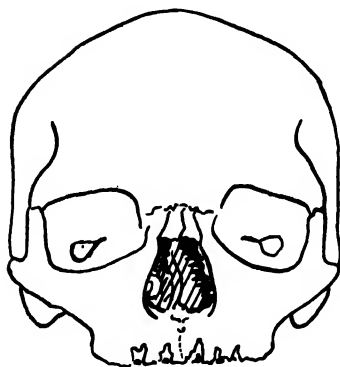
Fig. 292.   Type I.   Australian.
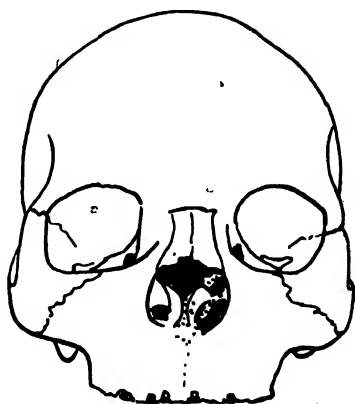
Fig. 293.   Type II.   African.
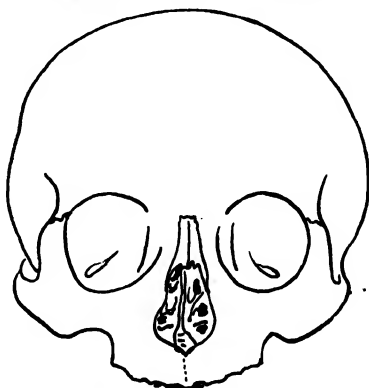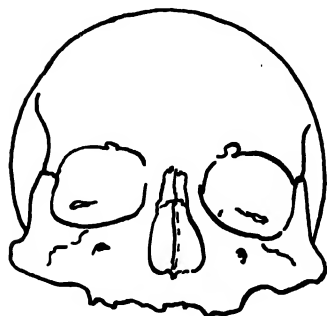
Fig. 294. Type III. Andamanese.

Fig. 295.   Type IV.   Eurasiatic, sub-division A.
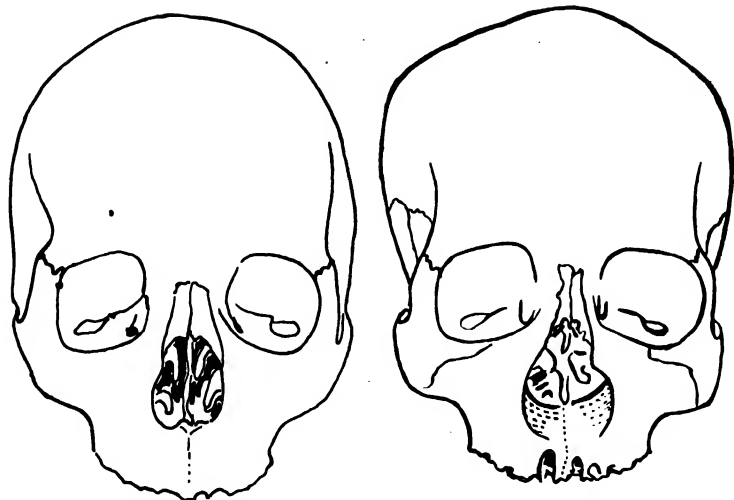
Fig. 296. Type IV. Eurasiatic, sub-division B.   Fig. 297. Type V. Polynesian.
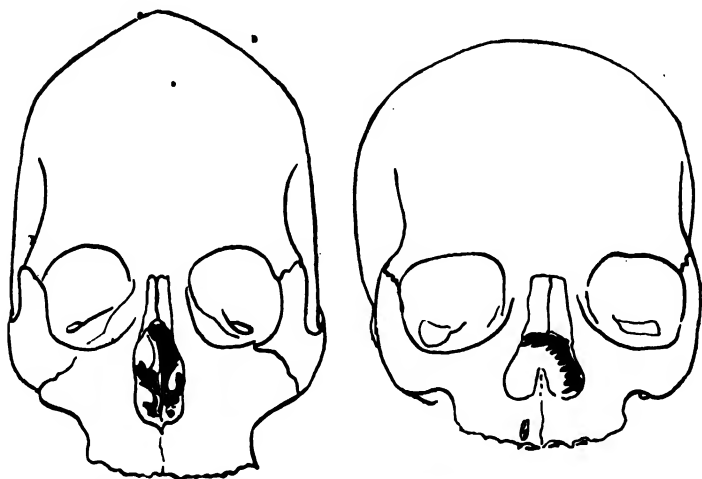
Fig. 298. Type VI. Eskimo.   Fig. 299. Type VII. South African.

· *Cranial Capacity.*   1246·5 c.c.

Cranial description.   The most striking features are the long narrow skull, the very prognathous face, heavy brow-ridges, and keeled cranial vault.

(*a*) Cranial portion. Long, narrow, phaenozygous, "ill-filled," scaphoid: muscular ridges distinct, temporal ridges closely approximated on parietal bone: the mastoid processes are small, but brow ridges and occipital lines are massive and prominent. Sutures simple: metopism very rare: fronto-squamous suture at the pterion in about 17 $\%$ of cases[1]. Grooves on the frontal bone are rare[2].

(*b*) Facial portion. Prognathous. Brow-ridges massive. Outer orbital margins bevelled: lacrymo-ethmoidal suture short. The nasal bones are flattened, slightly upturned inferiorly, wider above than below, and meet at an obtuse angle. The nasal aperture is wide, with indistinct lower margins: prenasal grooves are not uncommon, but the normal appearance is that described as orygmo-craspedote[3]. The palate is elliptical or hypsiloid: the teeth, especially the molars, are large: the tuber maxillare is large. The glenoid fossa is shallow, the styloid process very short, and anomalies in the region of the foramen magnum are frequent. The sigmoid notch of the mandible is shallow.

Associated characters. 1. *Stature.* The stature of males is about 1668 mm. (♀ 1568).

2. *Skeleton.* The cervical vertebral spines are not bifid, but slightly tuberous as in the Simiidae.

The lumbar curve of the vertebral column is not so pronounced as in white races, the lumbar index (107·8) being koilo-rachic and simian.

The male sacrum is sub-platyhieric or of mean proportions. The simian sacral notch is uncommon, though not unknown[4].

The proportions of the pelvis as a whole are often simian. But the ossa innominata are not specially simian in either sex.

The pelvic brim (in males) is dolichopellic and transversely narrowed.

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[1] In Tasmanian aborigines this suture hardly ever occurred, but in Mallicollo natives the percentage of occurrence is over 50.

[2] Cf. Dixon: *J. A. and P.* Vol. xxxviii. These grooves lodge branches of the supra-orbital and supra-trochlear nerves.

[3] Macalister, *J. A. and P.* Vol. xxxii.

[4] Turner's results have been modified by those of Paterson to the above effect.

The scapula is (paradoxically) narrower and less pithecoid than in white races.

The sternum is characterised by the frequency with which the pre-meso-sternal junction is at the level of the 3rd costal cartilage.

The sacral curvature is less than in Groups IV and V, greater than in Groups II and III.

Angle of humeral torsion (average) 134°5: (white races, 161°).

As regards the modifications, in form and in extent, of the articular surfaces of the femur, tibia, and astragalus in relation to the squatting posture, the skeleton in this Group only realizes expectation in a modified degree.

The proportions of the limb bones are simian as regards the tibio-femoral index, but not in respect of the other three indices (radio-humeral, humero-femoral and inter-membral).

3. *Skin.* Colour: chocolate-brown. (No. 8 of Topinard's series[1].)

4. *Hair.* Often abundant over the body in males: beard well developed: the hair is densely pigmented, black, and wavy (i.e. neither lank nor frizzled): the hair of the head is long. In children the hair colour is less intensely black. The hair follicle is straight. On transverse section, the contour of the hair is a broad oval (index 62—74).

5. *Eyes.* Iris dark brown: the sclerotic is not usually pigmented.

6. *Muscular system.* The cutaneous musculature is less differentiated than in Group IV.

7. *Brain.* In size and conformation, the cerebrum is distinctly inferior to that of the white races. (Cf. p. 432.)

Group No. II.

Synonym. African.

Distribution. The African Continent, with Madagascar[2].

Indices of Skull. *Average Value in Males* (cf. Figs. 277, 285, 293). Breadth 73·6. Alveolar 104·4. Nasal 56·8. Height 73·5.

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[1] For this series, quoted here and in subsequent pages, see page 353.

[2] In consequence of the widespread distribution of the African negro over the New World, this cranial form now occurs in the American continent.

Cranial capacity. 1388 c.c.; and much more variable than in Group I.

Cranial description. The skull is elongated and very prognathous, without marked brow-ridges: the nasal bones flat and uniform in width.

Cranial portion. Long, narrow, not constantly phaenozygous, not "ill-filled"; ridges less distinct than in Group, I; mastoid processes large, and styloid processes long: brow-ridges not typically prominent: metopism rare: fronto-squamous suture at pterion in about 16 % of cases (Ecker 20 %, Anutschin 12·8 %). Grooves on the frontal bones are very common[1].

Facial portion. Very prognathous: brow-ridges not prominent: sexual cranial differences often obscure: nasal bones flattened, not upturned, as wide above as below, meeting almost in the same plane: the nasal aperture is wide, with indistinct (orygmo-craspedote) inferior margins. The teeth, especially the molars, are large: anomalies in the neighbourhood of the foramen magnum are less common than in Group I.

Associated characters. 1. *Stature.* Male, 1620 to 1741 mm., and thus including some of the greatest human examples.

2. *Skeleton.* Lumbar curve: this is koilo-rachic, the anterior convexity being less distinct than in white races, but more definite than in Group I.

The male sacrum is similar to, or broader than, that in Group I; the sacral notch, a simian feature (Paterson), is normal and characteristic.

The sacral curvature is less than in any other Group.

The pelvic brim is wider than in Group I.

The proportions of the pelvis as a whole are sometimes simian: but this is not the case with the ossa innominata in either sex.

The scapula is more pithecoid and broader than in the white or yellow races.

Angle of humeral torsion (average) 144°: (white races 161°).

The modifications, in form and extent, of the articular surfaces in femur, tibia and astragalus in relation to the squatting posture, are only found in a modified degree.

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[1] Cf. Dixon, *J. A. and P.* Vol. xxxviii. The grooves are commonest in natives of West and South Africa, and in Egyptians.

The os calcis is stated to be unusually prolonged backwards.

The proportions of the limb bones are simian as regards the tibio-femoral index, but not so as regards the intermembral, radio-humeral, or humero-femoral indices.

3. *Skin.* The colour is typically intensely black, but variations towards dark chocolate-brown, or even bronze and reddish shades occur, as in, examples 7—10 inclusive, of Topinard's series of colour types.

4. *Hair.* The colour is jet black: the beard is scanty: the hair on the head is short and arranged in spirally coiled ringlets: the hair follicles pursue a curved course, associated with the frizzly character of the hair which on section has an elliptical contour (index 40—60).

5. *Eyes.* The iris is of a dark brown tint, and the sclerotic is in certain cases pigmented.

6. *Muscular system.* The system of cutaneous facial muscles is less differentiated than in Group IV.

7. *Brain.* The brain is absolutely larger than in Group I, but smaller than among, the white races. (Cf. p. 436.)

Group No. III.

Synonym. Andamanese.

Distribution. The islands of that name, the Malay Peninsula, the Philippines, while similar forms occur sporadically in other geographical areas[1].

Indices of Skull (cf. Figs. 278, 286, 294). Breadth 82·1. Alveolar 102·0. Nasal 50·9. Height 77·9.

Cranial capacity. 1266 c.c.

Cranial description. The skull is small and round, with prominent jaws.

Cranial portion. The skull is cryptozygous: muscular ridges are not very prominent: the mastoid processes are small, and the external auditory meatus shallow. Brow-ridges are not developed, and sexual differences are often obscure in these skulls. The frontal

[1] Small broad prognathous crania occur in ancient cemeteries in Peru. This must not be taken as a suggestion that the Andamanese natives ever formed part of the population of South America, for the only feature common to the two areas is the skull form, as judged by size, index of breadth, and the index of prognathism. Moreover, nearly all the Peruvian crania are artificially deformed.

bone very rarely joins the squamous portion of the temporal bone at the pterion.

Facial portion. The face is prognathous, the prognathism affecting chiefly the alveolar maxillary margin and being therefore sub-nasal: the brow-ridges are feebly developed in both sexes: the nasal bones are small, short, flat, and not wider below than above: they meet nearly in the same plane. The inferior nasal margins are indistinct.

Associated characters. 1. *Stature.* The association of a highly brachycephalic skull with dwarf stature is sufficient to distinguish this Group from Nos. I and II. The average stature for males is 1485 mm.

2. *Skeleton.* The lumbo-vertebral index denotes simian affinities (koilorachic class).

The sacrum is sub-platyhieric (according to Paterson) and characterised by the (simian) sacral notch. The sacral curve is very slight: it is somewhat greater than in Group II, with which this Group is hereby associated in the lowest position among the Hominidae.

The proportions of the pelvis as a whole seem to be rarely simian: with regard to the ossa innominata, the special human characters are here strongly marked in both sexes.

The scapula is the most pithecoid known among the Hominidae, with the possible exception of certain African dwarfs (Bambuté).

The proportions of the limb bones are simian as regards the radio-humeral and the tibio-femoral, but not as regards the inter-membral or humero-femoral indices.

3. *Skin colour.* Black, corresponding to Group 10 of Topinard's series of colour types.

4. *Hair.* The hair is scanty, and the beard sparse. In form, the hair is of the woolly or curly variety: in section the index of the hair would be probably about 50—60.

5. *Eyes.* The colour of the eyes is dark brown.

6. *Muscular system.* No data are on record.

7. *Brain.* No data are on record.

Group No. IV.

Synonym. Eurasian.

Distribution. The continents of Europe, Asia, and a large part

of America. As this form corresponds most closely to what may be called the generalised form of human skull, its wide distribution is thus intelligible.

Indices of the Skull. (Cf. Figs. 279, 280, 287, 288, 295, 296.) Breadth: all varieties occur, from the dolichocephalic to the brachycephalic form.

Alveolar · the index is also variable, but is usually less than 98: the skull is accordingly orthognathous.

Nasal: variable, but usually less than 48, and therefore leptorrhine.

Height: variable, but usually less than the breadth index, the height of the cranium being less than its breadth.

Cranial capacity. About 1500 c.c.. and consequently megacephalic.

Cranial description. The general description of the human cranium, as given in works on osteology is applicable to this group. Thus the typically human combination of a large cranium with a reduced facial skeleton is marked: the cranial surface is uniformly rounded: the temporal ridges are feebly marked, and lie far apart on the parietal bones. Sexual differences are often obscure. The sutural lines are very tortuous. A parieto-sphenoid junction in the temporal fossa is normal, the fronto-squamous suture occurring in about 1 % of cases. Grooves on the frontal bones are of rare occurrence[1].

The nasal aperture has sharp margins: the nasal bones are large, long, narrower above than below, and sharply inclined to one another. The palate is small, and in contour parabolic. The anterior lacerate foramen is widely open in the cranial base, the glenoid fossa is deep, and the styloid processes long.

Within so large a group, subdivisions must naturally exist, and the varieties of skull-form have been reduced by Kollmann to five sub-groups, based on the respective values of the cephalic and facial indices.

These groups are:

          (1)   dolichocephalic leptoprosopic,
          (2)   dolichocephalic chamaeprosopic,
          (3)   brachycephalic leptoprosopic,

[1] Cf. Dixon, *J. A. and P.* Vol. xxxviii.

(4) brachycephalic chamaeprosopic,

(5) mesaticephalic chamaeprosopic,

the mesaticephalic leptoprosopic sub-group being so small as to be negligible (at any rate in Europe).

Associated characters. 1. *Stature*: very variable, extending from 1540 mm. to 1790 mm. in males.

2. *Skeleton.* The lumbar portion of the vertebral column is strongly convex forwards, and therefore not simian.

The lumbo-vertebral index denotes the furthest separation from the simian form.

The index of ensellure is small (numerically only half that of Group VII).

The male sacrum is broad (platyhieric). The sacral notch is rare, and the curvature is great.

The proportions of the pelvis as a whole are rarely simian. In both sexes the ossa innominata have proportions more simian than those met with in any other Group.

The transverse diameter of the pelvic brim is relatively great, with proportionate diminution of the sagittal diameter; the brim is thus platypellic.

The scapula is narrow in proportion to its length: it does not however occupy the position furthest removed from the pithecoid type.

The angle of humeral torsion averages 161° (Broca).

The proportions of the limbs as regards the inter-membral, radio-humeral, tibio-femoral and humero-femoral indices are either indifferent or not definitely simian: they are in certain instances nearer the simian type than those of the three preceding groups (notably in respect of the inter-membral index).

3. *Skin.* The skin is very variable in colour, the range extending from the fairest blonde of Scandinavia to the ebony blackness of the Abyssinian (the whole range of Topinard's series of colour types).

4. *Hair.* The hair-colour is also very variable: the extremes are represented by Scandinavian blondes and by the negroid Abyssinians, or by the natives of Hindostan. The degree of hirsuteness is also variable, as seen in the contrast of the Ainus with the Javanese.

The hair follicle is straight in direction, and the transverse sections of hair approach in contour to a circle rather than to an ovoid or elliptical figure, with an index of about 65—70.

5. *Eyes.* The pigmentation of the iris varies in tint from the lightest grey to the darkest brown, commonly called black.

6. *Brain.* The description of the brain as given in anatomical text-books applies to this Group. Associated with a cranium of great capacity, the brain is very large, weighing about 1330 gm. on the average: its convolutions are extremely tortuous, and operculation of the central lobe is complete. The sulcus lunatus and occipital operculum are not however unknown, though statistical data as to the frequency of their occurrence are still lacking.

Group No. V.

Synonym. Polynesian.

Distribution. Islands of Polynesia, viz. from Rotumah to Easter Island, and from the Sandwich Islands to the Chatham Islands.

Indices of the Skull. (Cf. Figs. 281, 289, 297.) Breadth 80·4 (Hawaii). Alveolar 98·6. Nasal 47·9. Height 75·5.

Cranial capacity. 1469 c.c.

Cranial description. The skull is large, and distinctly rhomboid in shape, when seen from above, the appearance being due to the development of the parietal eminences.

Cranial portion. The frontal bone recedes rapidly from the glabella backwards, and the parietal region appears voluminous. The brow-ridges are not prominent. Grooves on the frontal bone are rare[1].

Facial portion. There are large pre-nasal fossae below the apertura pyriformis nasi, the fossae being bounded anteriorly by the nasal margin of the maxilla, while posteriorly a second maxillary ridge descends to the floor of the nasal fossa. The nasal aperture is narrow, sometimes extremely so; the nasal bones though long, are narrow: they meet at an acute angle.

The angle of the mandible is much rounded, so that measurement of the value of the angle is rendered difficult.

Associated characters. 1. *Stature.* The average stature varies

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[1] Cf. Dixon, *J. A. and P.* Vol. xxxviii.

from 1680 mm. to 1743 mm. (Deniker), including therefore some of the tallest examples among the Hominidae.

2. *Skeleton.* The lumbar portion of the vertebral column. The lumbo-vertebral index denotes simian affinities (cf. Turner's figures for Oahuans; the number was however only three), but data are scanty.

The sacrum is broad, and enters into the platyhieric group. The simian notch is rare. As regards sacral curvature, no sure data are available.

The proportions of the pelvis as a whole are far removed from those of the Simiidae, and a similar remark applies to the ossa innominata in both sexes.

The scapula presents typical human proportions, and occupies an intermediate position, in the scale of races arranged according to their scapular proportions.

Angle of humeral torsion (average) 144°: (white races 161°).

As regards the proportions of the limb bones, this group occupies an indefinite, or indifferent, position.

3. *Skin colour.* Café-au-lait, or warm brown, corresponding to No. 5 in Topinard's series of colour types.

4. *Hair.* Black: wavy, or straight, with a sectional index of about 62. The beard is scanty or absent.

5. *Eyes.* The iris is of a dark brown colour.

6. *Brain.* The brain of a Marquesas islander was characterised by a simpler plan of convolutions than the brains of white men[1]. In one Polynesian brain the sulcus lunatus has been observed[2].

Group No. VI.

Synonym. Greenland.

Distribution. Greenland, Labrador, and thence sporadically along the northern coast of America to the eastern portion of the north coast of North Asia.

Indices of the Skull. Averages for males. (Cf. Figs. 282, 290, 298.) Breadth 71·5. Alveolar 100·6. Nasal 45·3. Height 73·7.

Cranial capacity. 1546 c.c. (megacephalic).

Cranial description. The skull is large, elongated, and very

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[1] Cf. p. 440 *supra.*　　　　　[2] W.L.H.D. (specimen at Paris).

scaphoid, with immense malar bones, very narrow nasal aperture, and flattened face.

Cranial portion. Dolichocephalic, cryptozygous, scaphoid without sagittal synostosis: muscular ridges not prominent: mastoid processes large: brow-ridges not large; styloid processes stout and long: posterior margin of foramen magnum often notched. Sutures simple. Grooves are rare on the frontal bones[1].

Facial portion: no prognathism: the index shews that mesognathism is the rule.

The orbits are high, and the infraorbital sutures often persist (in adults) on the facial surface.

The nasal aperture is narrower than in any other Group. The nasal bones are long, narrow, and inclined at an acute angle to one another: the canine fossae are very shallow and often non-existent, as the maxilla is prominent in this region. The mandible is broad, and the gonio-zygomatic index, 82·5, provides the highest known figure in the Hominidae[2]. The mandible often presents a curious thickening which affects chiefly the body.

Associated characters. 1. *Stature.* The average stature of males is 1621 mm. (Deniker)[3].

2. *Skeleton.* The lumbo-vertebral index assigns to this Group a place lower than Group IV (the highest), but the difference is not great. The Group is orthorachic.

The sacrum is broad (platyhieric) and the simian notch does not seem to be on record for this Group. No sure data are available as regards the sacral curvature.

Pelvic index. The proportions of the pelvis as a whole, and of the ossa innominata, are not simian in either sex.

The proportions of the scapula are intensely human.

The proportions of the limb bones are simian in respect of the intermembral and humero-femoral, but not in respect of the radio-humeral or tibio-femoral indices: the determining factor is the great relative length of the humerus.

3. *Hair.* The hair is black and lank; it is not abundant, nor

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[1] Cf. Dixon, *J. A. and P.* Vol. xxxviii.

[2] Sören-Hansen, *Meddelelser om Grönland*, Part x.

[3] Sören-Hansen (*op. cit.*) gives an average of 1606 mm. for 140 men, 1506 mm. for 110 women.

is the beard constantly developed: in section the hair is nearly circular, with an average index of about 80. (Latteux: quoted by Topinard, *El. d'A.* p. 279.)

4. *Skin.* The skin colour is variable, within the range of the lighter shades of yellow, i.e. Nos. 4 and 5 of Topinard's series of colour types.

5. *Brain.* No Group provides a heavier (average) cerebrum than this.

6. *Other features.* The epicanthic fold at the inner angle of the eyelids is common, though not universal.

Group No. VII. (Cf. Figs. 300 and 301.)

Synonym. South African: the aboriginal natives of this group are rapidly disappearing. They are quite distinct from the true Negroes or Kaffirs.

Distribution. A limited extent of South Africa, and sporadically in other parts of Africa.

Indices of the Skull (average male). (Cf. Figs. 283, 291, 299.) Breadth: from 74 to 75, just on the limit of dolichocephaly: the females are distinctly mesaticephalic. Alveolar: mesognathous (101·5, Shrubsall), inclining to orthognathism; this is a distinctive feature of the group. Nasal: 60·2 (extremely platyrrhine). Height: lower than the breadth index (70·8).

Cranial capacity. 1331 c.c. (microcephalic).

Cranial description. The skull is small, with flattened face, small jaws, and remarkably vertical forehead; the brow ridges are insignificant. The aspect is thus infantile.

Cranial portion. The skull is cryptozygous; well-filled, i.e. uniformly rounded, not scaphoid; the brow-ridges and mastoid processes small or insignificant: the temporal ridges widely separated on the parietal bones. The sutures are simple, wormian bones uncommon, and the fronto-squamous suture at the pterion is rare. The sagittal median line of the contour is marked by a flattening or depression, post-bregmatic in position, and the occipital contour is rounded and bulging. Grooves are common on the surface of the frontal bones[1].

Facial portion. The face is small in proportion to the cranial part, even for a human skull. The facial profile is remarkably

[1] Cf. Dixon, *J. A. and P.* Vol. xxxviii.

flattened, and if prognathism occurs, it is sub-nasal, affecting the alveolar margin of the maxilla: the nasal bones are very flat, and the characters of the nasal aperture exactly reproduce those of

Fig. 300.   Fig. 301.

Fig. 300.   Bush-man of South Africa[1].

Fig. 301.   Bush-woman of South Africa.   The characteristic features of the hair of the head, and the accumulation of gluteal fat (steatopygia) are evident in this individual.

[1] Figs. 300, 301, and 216 (v. supra) have been kindly lent by Messrs H. Scott & Co.

African negroes of normal size (Group II).   The palate is shallow and elliptical, the mandible feebly developed, the chin not prominent and the sigmoid notch shallow.

Associated characters. 1. *Stature.* The average stature is 1529 mm. in males (Deniker).

2. *Skeleton.* The lumbo-vertebral index (koilo-rachic class) denotes simian affinities.   The index of ensellure is on the average (4 examples) 7·2 (numerically twice that of Group IV).

The sacrum is very simian: it is elongated (dolichohieric): the simian notch occurs in about 33·3 % of examples.   The sacral curvature is relatively very slight.

The curvature of the iliac crests is distinctly less than in Group IV, and indeed most other Groups: the pelvis is simian in this respect.

Pelvic index.   The proportions of the pelvis as a whole are more nearly simian than in any other Group.   The os innominatum is simian or infantile.   In his description of a bush pelvis Cleland[1] notes the number of infantile features provided by it, as for instance, the lack of development of the posterior parts of the ilia: the growth of these is considered by Thomson[2] as the most important factor in producing the increase in transverse diameter which occurs in white races (previously the increase had been largely ascribed to transverse sacral growth).

As regards scapular proportions, the South African Group occupies an intermediate position in the human series.

The proportions of the limb bones, as judged by the inter-membral, radio-humeral, and humero-femoral indices, are not simian.

3. *Skin.* Clear yellow in colour, corresponding to No. 4 of Topinard's series of colour types.

4. *Hair.* The hair is not abundant: the males have little or no beard: the hair of the head is distributed in the "peppercorn" manner: the hairs are tightly coiled, and in section present a very flattened elliptical contour (index about 46).   The hair follicle is curved.

5. *Muscular system.* The facial cutaneous muscles are less differentiated than in white men.

[1] *British Association Report.*   [2] *J. A. and P.* xxxiii.

6. *Other characters.* Both sexes, but particularly the females, are characterised by steatopygia, or the gluteal accumulation of fat (cf. Chapter XIV. p. 361 and Fig. 301). In the females, the labia minora are hypertrophied and elongated to an extraordinary and characteristic degree.

MORPHOLOGICAL CHARACTERS OF THE PYGMY RACES.

In drawing up the scheme to demonstrate the chief morphological types of the Hominidae, the presence among the seven representatives selected, of two races of pygmy stature and proportions, was remarked[1].

The inclusion of these pygmy types was unavoidable, inasmuch as the tests first imposed related not to stature (which would at once have ruled all pygmy races out of further direct comparison with the taller races), but to the proportions of the skull. It is suitable to add brief notes on the very remarkable pygmy types now known to exist in certain parts of the world, and a few words will finally be added in description of the remains of pygmy individuals supposed to be the relics of a pygmy stock once inhabiting Europe. The descriptions will be arranged, not according to the morphological characters, but according to the particular race, so that the following pygmy groups will be considered, in addition to those (the Andamanese and the Bush natives of S. Africa) already described.

I. (A) The Central African group, (B) the Semang of the Malay Peninsula, and (C) the Aëta of the Philippine Islands. II. The Veddah of Ceylon. III. Prehistoric European pygmies.

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[1] It is to be noticed that all dwarfs do not possess similar proportions. Dr Birkner (in a pamphlet entitled "Einiges über Zweigenwuchs") has made a very useful contribution to the subject of dwarfishness, if the adaptation may be permitted, or Nanism. His observations were made on dwarfs from Burmah and from Ceylon. He makes out a good case in support of his proposition to the effect that there must be distinguished varying degrees of dwarfishness, or what may be styled total nanism and partial nanism; the essential difference between the total and partial forms consisting in the fact that true (total) dwarfs possess, in respect of limbs and trunk, the proportions obtaining in adults of normal size; whereas, in the partial or pseudo-dwarfs (partial nanism), the trunk is relatively longer and the legs proportionately shorter than in normal adults; herein dwarfs of the latter class retain the infantile proportions.

Dr Birkner believes that the so-called dwarf races will, when such a discriminating investigation is brought to bear on their physical proportions, present us with examples of each class; and he surmises that the Asiatic pygmies may very probably fall into the category of partial dwarfs. To this a provisional assent may be accorded, though it is believed that the dwarfs of infantile proportions are more primitive than the "true" dwarfs as defined by Birkner.

The geographical distribution of the pygmy races is indicated in the accompanying sketch-map (Fig. 302).

Fig. 302.   Map to represent the distribution (x) of pygmy races of Man.

DWARF GROUP.   I (**A.**)

Name.   Central African.   (Cf. Fig. 303.)   Three groups, viz., Bananda, Bambute, Baamba, have been carefully investigated[1].   Many other tribes, such as the Akka, Batwa, etc., await research.

Stature.   1452 mm. (in the Bambute).

Distribution.   Uganda and adjacent regions.

Cranial indices:

Breadth.	79·2 (Bambute ♀).	The Akka dwarfs are in certain instances dolichocephalic (74·4 in a male skull).
Alveolar.	107·4 (Bambute ♀).	This figure is exceeded by that (108·7) of an Akka dwarf (♂).
Nasal.	58·7 (Bambute ♀).	This figure is exceeded by that (63·4) of an Akka dwarf (♂).
Height.	70·2 (Bambute ♀).	

Cranial capacity.   1400 (Bambute ♀).   The Akka skulls are less capacious (1070—1100 c.c.).

Cranial description.   (Cf. Shrubsall's account of the Bambute skull now in the British Museum.   The account will be found in Johnston's *Uganda Protectorate*, Vol. II.)

(*a*)   Cranial portion.   Small, but not infantile : oval in norma verticalis : the sutures not tortuous, the individual being advanced in years ; ill-filled :

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[1] See Shrubsall's reports in Johnston's *The Uganda Protectorate*, Vol. II.
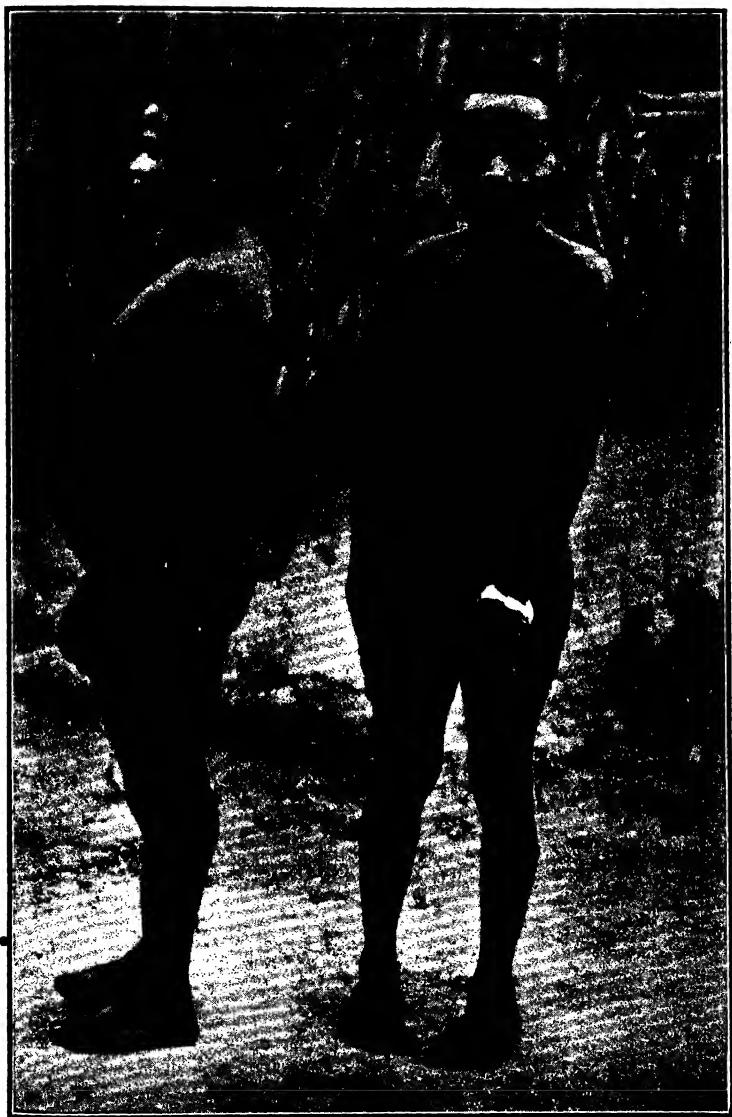
Fig. 303.   Two Bambute pygmies from Central Africa (from a photograph kindly lent by Sir H. H. Johnston).

ridges and mastoid processes are inconspicuous. The sphenoid joins the parietal bone at the pterion. In the two Akka skulls in the British Museum, the frontal and squamous bones join. A brief note on these skulls follows the present account.

(b) Facial portion. The jaws are prognathous to a high degree (this character is probably even more pronounced in the Bananda). The orbit is almost microseme, with small vertical diameter : the nasal aperture is wide, the nasal spine small : simian grooves are present : the nasal bones are flat and meet at a wide angle, thus lying nearly in the same plane. ' The palate is elongated and narrow : the teeth large.

The mandible is slight, not massive ; the condylar and coronoid processes are short (i.e. infantile): the sigmoid notch also infantile, being shallow : the chin is pointed. There are general resemblances to Bush and to Akka crania.

Three skulls of pygmies from Central Africa are in the Museum at South Kensington. One of these is the Bambute skull already mentioned, the other two are skulls of Akkas and have been described by Flower (*Journal of the Anthropological Institute*, Vol. IX. 1880). The following notes have been made by myself, in reference to certain features not specially dwelt on by other observers.

I.   Akka skull (? ♀); with skeleton.

The spheno-maxillary fissure is widely open. 'On both sides the frontal and squamous-temporal bones join in the region of the pterion. The lacrymo-ethmoidal suture is not unusually short. The nasal margins are distinct. No special features were noted in the teeth.

II.   Akka skull (♂); the frontal and squamous bones join on the right side, but on the left the sphenoid and parietal bones just touch at the pterion. The lacrymo-ethmoidal suture is distinctly short, and the nasal aperture small. No specially simian features occur in the teeth ; the third upper molar teeth are reduced in size as compared with the other molar teeth : the third lower molar has a remarkably circular crown which is crenated. The palate is elliptical in contour. No other features of importance are seen at the base of the skull. This specimen is less prognathous than the following.

III.   Bambute (♀). This specimen is very prognathous, and the spheno-maxillary suture is widely open ; no special features characterise the teeth: the sphenoid and parietal bones touch at each pterion. The lacrymo-ethmoidal suture is not unduly short.

The nasal margins are obliterated inferiorly ; at the cranial base small paroccipital processes are seen on each side.

Lumbar curve. The vertebral column is koilo-rachic (index 102) but less so than that of the Akkas (index 102·6).

Pelvis. The bones are slight : the iliac crests are less tortuous than in tall races: the brim-index is dolichopellic (95·8) as in Bush and Andamanese dwarfs : the breadth-height index is a simian feature, its value is variable,

between 89·5 and 111·7 In Europeans the value is 74 (a Bush native had an index of 91).

Scapula. The index (87·9) is extraordinarily low and simian, or even "therian."

Femur. The neck joins the shaft at an angle of 138°.

The upper limb bones. The fore-arm is long in comparison with the arm: the radio-humeral (ante-brachial) index being 79·7. This is a slightly simian feature. Living Bambute provide an average index of 91·6 (range 80—100·1), but allowance must be made for errors, due to the presence of soft tissues in the living.

The lower limb bones. The tibio-femoral index (84·1) is dolichocnemic in the living subject (Bananda, Bambute, Baamba).

The humero-femoral index. Denotes a very long humerus (index = 80·3) as determined in the living subject.

The inter-membral index. The index in the living is on the average 83·63, this figure indicating much longer upper limbs than in the tall races. (Cf. Chapter XIII. p. 331.)

Skin colour. The Uganda dwarfs present two varieties, viz. (*a*) reddish-yellow, (*b*) jet-black.

Hair colour and character. The dwarfs with reddish-yellow skins, men, women, and children alike, are characterised by the possession of a fine downy lanugo-like covering of hair of reddish tinge, longer on the legs and back, and not tightly curled except that the axillary and pubic hair, like that of the head, is tightly curled. The jet-black dwarfs have also hair on the body, but more curly than in the foregoing group. Males of both types have a slight moustache and sometimes a distinct beard. Women of type (*a*) have often a trace of whiskers. All are less hairy than the dwarfs of the Congo region. The hair of the head is lightly curled in all as in negroes. In variety (*a*) the hair is never absolutely black in colour; it varies from an indefinite grey-green-brownish tint to a reddish tinge, the latter colour being more pronounced on the more anterior parts of the head.

Miscellanea. The alae nasi are very large and rise as high as the central part of the nose: this feature distinguishes the pygmy physiognomy from that of the tall African negroes. In the prognathous pygmy type (Banande) the long upper lip is a distinctly simian feature; the mouth is large, but the lips are not so everted as in some negroes: the chin is receding.

Steatopygia is never so marked as in the Bush race; in the Uganda group (*a*), the buttocks may be even attenuated; this is a simian feature: the upper limbs are longer and the lower limbs shorter relatively than in the tall negroes of Africa, and are therefore infantile. The feet are well formed and the toes long; the hallux diverges from the smaller toes. Non-simian characters are the narrowness of the jaws and the small numerical value of the index of the external ear, in which these pygmies approach the white races.

Of the anatomy of the soft tissues nothing is as yet known.

DWARF GROUP.   I (**B**).

Name.   Semang[1].   (Cf. Fig. 304.)

Stature.   1525 mm. (av. of 23 ♂); 1445 mm. (av. of 3 ♀).

Distribution.   Limited areas in the Malay Peninsula.   Comparatively few pure-blooded individuals exist.   Remnants of another dwarf stock, the Sakei, inhabit the same region, but whereas the Semang agree with the Andamanese, the Aeta, and the Central African pygmies in the important characters of
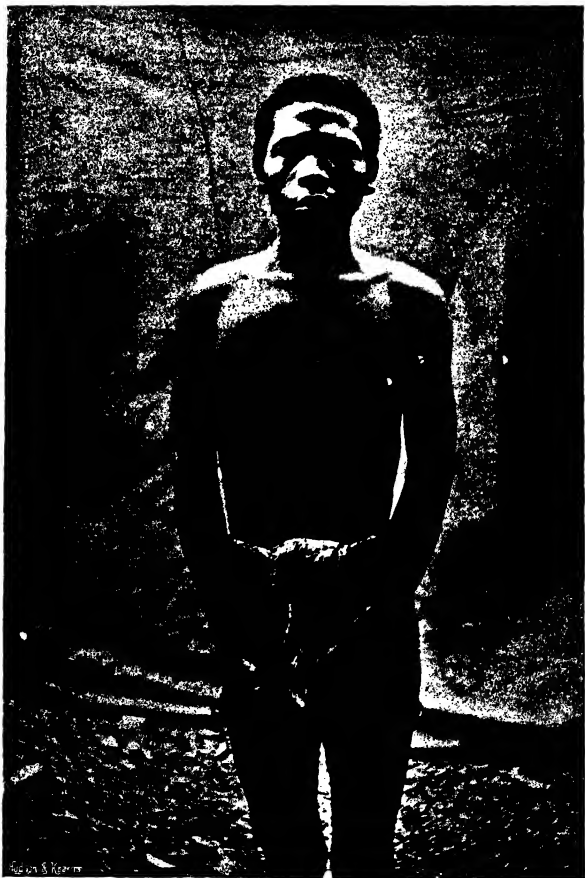
Fig. 304. A young Semang negrito from the Malay Peninsula.   (From a photograph kindly lent by Dr N. Annandale.)

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[1] Cf. Skeat, *Wild Tribes of the Malay Peninsula* ; also Annandale and Robinson, *Fasciculi Malayenses.*

hair form, the Sakei resemble the Veddah group, in which the hair is not crisp and curly, but wavy. The Sakei will not be further considered here.

Cranial indices:

Breadth.   76·2 (av. of 4); in the living the index is 77·7 (av. of 20 ♂).
Alveolar.   99·7 (av. of 4, viz., Annandale 2; Skeat 1, Grubauer 1).
Nasal.   57·4 (av. of 3, viz., Annandale 2; Skeat 1: Grubauer's
                  specimen is purposely excluded).
Height.   77·3 (av. of 2; viz., Skeat 1, Grubauer 1).

Cranial capacity. 1230 c.c. (av. of 5, viz., Annandale 2, Turner 1, Skeat 1, Grubauer 1, Virchow 1).

Cranial description. For this purpose the Semang skull now in the Museum of the Royal College of Surgeons in London is appropriate (cf. *Man*, 1903, No. 18). Evidence of a low grade of evolution is not presented, and the specimen is distinctly less simian than the Bambute skull, being less prognathous and having a narrow nasal aperture.

The cranial portion. This is not "ill-filled"; but the brow-ridges are prominent: in form the skull may be described as ovoid though short: muscular ridges are not prominent.

The facial portion. Prognathism is of the subnasal variety: the orbits are microseme, the nasal aperture is leptorrhine as judged by the index, but allowance must be made for an unusually prominent nasal spine: the palate is long and hypsiloid. The chin is prominent (such prominence is absent in the living subject), the shortness of the ascending ramus of the mandible and shallowness of the sigmoid notch constitute infantile features.

Lumbar curve. The index (97·5) shews that the vertebral column is kurto-rachic, approximating to the type of the white races of tall stature.

Pelvis. The iliac crests are less tortuous than in the tall races of Man: herein the Semang agrees with the Bush and other dwarf types.

Scapula. The average index (84·4) for the scapulae of a Pangan Semang shews a distinctly simian feature.

The upper limb bones. The fore-arm is of moderate length as compared with the upper arm: the result of observations on living Semangs shews that the fore-arm is excessively long, but allowance must be made for the error involved in measuring, which probably accounts for the discrepancy of results derived from the skeleton and from the living subject respectively. A precisely similar lack of correspondence in this respect is revealed by the data provided by those who have examined the African pygmies and the Veddahs respectively.

The lower limb bones. Messrs Annandale and Robinson (*Fascic. Malayenses*, 1903) note that the linea aspera of the femur is prominent, that the gluteal ridge is feeble, and no third trochanter was seen in four femora examined by them. In the Semang femora at Cambridge (Skeat Coll.) the femora are very slender at their lower ends, herein resembling Bush-native femora. The tibial head would seem to be retroverted (cf. *Fascic. Malayenses*, I. p. 156).

The intermembral index. This index is provided by the skeletons described in the publication just referred to (*Fascic. Malayenses*, p. 156): the average from four limbs is there given as 67·6. This figure removes the Semang further than the white races from the anthropoid apes. (Cf. Chapter XIII. p. 331.)

The humero-femoral index. The authors of *Fasciculi Malayenses* record figures which provide 69 as the average value of this index in four limbs of Semangs: and judged by this index the Semangs are further removed from the anthropoid apes than are the white races. (Cf. Chapter XIII. p. 339.)

Skin colour. This is of a dark chocolate-brown, passing through dark sepia into black.

Hair. The colour is black: in character the hair is woolly, short, crisp curls being distributed in peppercorn fashion over the head. Chin-hairs are scanty and a beard is rarely developed. As regards the presence of a down-like hair covering on the limbs and trunk, no observations are accessible at present.

Eyes. The colour is described as black or dark reddish-brown.

Miscellaneous notes. The general features of the physiognomy are strikingly similar to those of the Central African dwarfs; especially perhaps in the development of the alae nasi and consequent breadth of the nose, and in the width of the face. As in the African varieties, the forehead has often the character termed *bombé* by the French. The lips are said to be full and everted, but not thick.

Steatopygia does not occur. To judge from photographs, the extremities are delicately formed, and the tracings of feet provided by Messrs Skeat and Laidlaw exhibit a slight but definite divergence of the axis of the great toe from those of the smaller toes.

DWARF GROUP.   I (C).

Name.   Aëta.

Stature.   1480 mm.

Distribution.   The islands of the Philippine group.

Cranial indices:

Breadth.   79·6 (av. of 4, *Crania Ethnica*) to 83·4 (Virchow, *Z. f. E.*, 1871). In the living 84·7 (18), (Montano), or 87·5—90 (Miklucho-Maclay, *Pet. Mitt.*, 1874, p. 22). Artificial deformation has however to be taken into account.

Alveolar.   In some cases very marked prognathism is seen, but the value of the alveolar index can not be calculated from the data available.

Nasal.   53·6 (av. of 3, *Crania Ethnica*), this shews a moderate degree of the Platyrrhine character.

Altitudinal.   74·4 (*Crania Ethnica*) to 77·1. (Virchow, *Z. f. E.*, 1871.)

Cranial capacity.   1419 (av. of 4, *Crania Ethnica*), the range being from 1310 to 1535.

Cranial description:

(a) General. The skulls are brachycephalic, though not to a very high degree: the texture is fine and the surface in general smooth.

(b) Cranial portion: the cranial vault is uniformly rounded, and not "ill-filled": the parietal and sphenoid bones join at the pterion.

(c) Facial portion. The nasal bones are of moderate size and taper upwards: the nasal aperture is of moderate width only: the maxilla is prognathous, the effect being largely due to prominence of the alveolar margin (sub-nasal prognathism). The chin is not prominent, but on the other hand the ascending ramus of the mandible is massive and long. In general, the characters of the skull are not suggestive of simian affinities.

Only one skeleton appears to be available for examination. Up to the present a detailed account is still lacking. No information is accessible regarding the characters of the lumbar vertebrae or of the pelvis, except that the sacral notch (a simian feature) is well-marked. (Virchow, *Z. f. E.*, 1871.)

Upper limb bones. The radio-humeral index. It is surmised[1] that this index is about 80 on the average: Virchow quotes figures yielding an index of 78 (*Z. f. E.*, 1871); this shews but a slight simian resemblance, and falls short of that provided by the Andamanese pygmies, though it is approximately the same as that of the Semang (*q. v.*).

Lower limb bones. The tibia is (in the only skeleton known) platycnemic. (Virchow, *op. cit.*) The tibio-femoral index (80, Virchow, *op. cit.*) does not provide any special indication.

The humero-femoral index. Virchow's figures provide an index of 71, which has no special significance.

The intermembral index. The figures provided by Virchow yield an index of 70. This shews a greater length of the lower extremities than in most dwarf races. In this respect the Aëta approaches the Veddah.

Skin. The colour of the skin is compared to dark copper by some writers (Montaño), while others use the expression "sooty-black" (Symes and Fichte).

Hair. The hair of the head closely resembles that of the Andamanese, of the Semang, of the Central African pygmies and of the Bush race, in consisting of small discrete and closely coiled curls distributed over the head in the manner described as "peppercorn." The beard is not commonly developed and herein the Aëta and Semang are closely similar.

Eyes. Jet-black in colour, according to Foreman.

Miscellaneous. From photographs of the Aëta, it appears that the face is broad, the nose very broad owing to the large size of the alae, the lips protuberant, but not everted. The general aspect of the Aëta physiognomy is however less infantile than in the case of the Semang and Andamanese, suggesting rather the physiognomy of certain of the negro races of Oceania.

The whole subject of the distribution of the Negritoes has recently been

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[1] Sarasin Brothers.

exhaustively discussed by Dr A. B. Meyer of Dresden, so well known from his researches in Negrito ethnology.   The work in question, entitled *The Distribution of the Negritoes,* was published by Messrs Stengel and Co. in Dresden (1899).

DWARF GROUP.   II.

The next group, the Veddah, differ in such important points from the preceding pygmy types, that though described in series with these, the differences must always be kept in mind.   The pygmy races already described agree in the possession of short, curly hair, crania which are either short or of moderate proportions, and upper limbs which in comparison with the lower limbs are relatively long (this being an infantile character).   They are all truly pygmy in stature.

But the Veddah are distinctly taller, and also differ from the foregoing pygmies inasmuch as their hair is long and wavy, their crania are very elongated, and their upper limbs are comparatively short.   And while they thus differ from the veritable pygmy races, they agree with certain black tribes of Southern India, with some of the Sakei of the Malay Peninsula and, though to a less degree, with the aborigines of Australia.   So it seems probable that the distinction is a real one and that two definite stocks were here recognisable.

Nevertheless, since so much has been written about the Veddah and so many simian traits are alleged to occur in their structure, it seems desirable to treat of them in the present connection.

Name.   Veddah.

Stature.   1576 mm. (av. 71 ♂)[1], 1473 mm. (28 ♀).

Distribution.   Ceylon only: allied types occur sporadically in Southern India, where it is not a little remarkable that genuine "Negrito" aborigines have not yet been discovered, despite Lapicque's statements (1904).

Cranial indices:

Breadth.   71·5 (♂), 71·4 (♀).   Distinctly dolichocephalic.   In living subjects the index is about 75.

Alveolar.   95·2 (♂), 94·1 (♀).   Distinctly orthognathous; but the teeth are prominent.

Nasal.   52·7 (♂), 51·7 (♀).   Mesorrhine; small simian grooves are not infrequent.

Height.   74·1 (♂).

Cranial capacity.   1250 c.c. (for ♂); 1140 c.c. (for ♀): in some women the capacity of the skull is very small (hardly exceeding 900 c.c.)

Cranial description:

(a)   General.   Muscular crests and ridges are not well marked: the weight of the skull is (on the average) 574 gm. in men, 521 gm. in women.

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[1] Sarasin, *Ergebnisse,* p. 88 *et seq.*   This work is of the first importance in connection with the Veddahs.

(b) ˚Cranial ·portion. The skull is dolichocephalic, the lateral parietes being flattened, the temporal region not bulging, the foramen magnum not directed so far forwards as in the white race, and the occipital region less prominent . than in these. The extreme dolichocephalic proportions distinguish the Veddah very clearly from other pygmy types.

(c) Facial portion. Prognathism is due to the projection of the teeth only : the orbits are not so vertically flattened as in the other dwarf types : the. palate is of moderate dimensions : the mandible is slight, the chin being distinctly, though not markedly, prominent.

Lumbar curve. This is koilo-rachic, with an index of. 103·5 (av. 8 ♂), but ortho-rachic (99·9) in women.

Pelvis. This is narrower and higher, and therefore more simian, than in the white races, the breadth-height index being 80·9 in men, 78·9 in women (cf. Europeans, 73). The brim index is 89·9 for men, 88·2 for women, and thus platypellic, the type of the most highly developed Hominidae.

. *Scapula.* The principal feature is the obliquity of the axis of the spine. The index is greater than in European scapulae. These features are simian.

Humerus. The per-centage (58) of perforated olecranon fossae is very high.

Femur. The third trochanter is not common ; when present, it is usually small.

Upper limb bones. The skeletons yield a radio-humeral index of the following values; for 8 ♂, 79·8; for 2 ♀ 78·8, with a range from 76·5—83·4. The proportions are thus of the same mean value as in the Semang : but when the figures for the living Veddah are examined, the indication is seen to lack corroboration from the skeletal proportions, just as is the case in the data for African pygmies and for the Semang. The method employed would seem to be in fault. The index (radio-humeral) for living Veddah men is 91·9 on the average.

Lower limb bones. The tibia is not platycnemic : the tibio-femoral index is 86·1 (for 7 ♂), or 84·7 (for 3 ♀). These figures indicate simian tendencies.

The humero-femoral index appears from the measurements of the Sarasins to be about 71, which is not very different from those of the white races, though far below (i.e. the humerus is far shorter than that of) the Central African pygmies.

The intermembral index. The average values for this index are 68·7 or 69·1 (7 ♂), 67 or 67·4 (for 2 ♀) according as the tibial spine is included or not in the measurement : no simian resemblance can be detected here, and further the proportion does not indicate an infantile trait ; in this respect the Veddahs are to be distinguished from the infantile type of dwarf.

Skin. The skin-colour varies from tribe to tribe, and even in one and the same individual the tint is not uniform throughout the whole extent of the body. No less than twelve tints have been described, but it is noteworthy that while a variety of browns from "yellowish-brown" through "reddish-brown" to "dark-brown," are mentioned, in no case and in no region is the skin jet-black.

Hair. The hair is coarse, wavy, not woolly, uniformly distributed over the head, not "peppercorn" and always black. The beard is scanty and so is the distribution of hair on the body generally. A few individuals have rather hairy legs.

Eyes. The colour is described as black-brown or dark-brown (Nos. I and II of Broca's tables).

Miscellanea. The brothers Sarasin, who have so extensively investigated the characters of the Veddah, give the following list of characters in which this race presents simian affinities, as compared with the white races.

(1) The proportionately larger development of that part of the skull which lies anteriorly to the auditory meatus.

(2) The greater downward growth of the frontal bone on the inner orbital wall.

(3) Small stature and cranial capacity.

(4) More upright cranial walls.

(5) More flattened contour of cranial vault.

(6) Great proportionate length of fore-arm as compared with arm.

(7) Greater frequency of perforation of the olecranon fossa humeri.

(8) Greater frequency of junction of squamous bone and frontal bone in the region of the pterion.

While against these must be placed the greater elongation of the lower as compared with the upper limbs.

DWARF GROUP. III. PREHISTORIC PYGMIES' OF EUROPE.

In interments referred to the neolithic period at Schweizersbild in Switzerland, Kollmann found remains of human beings of pygmy stature. Some of the chief features of these skeletons are reviewed in the following notes:

Stature. Three skeletons are considered to be those of mature women, and the average stature computed from the femoral length is stated by Kollmann to be 1424 mm. (cf. female Veddah, 1433 on the average), Pearson's calculations reducing this figure to an average of about 1410 mm.[1]

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[1] The last-named observer applying the most elaborate methods to the determination of stature from measurements of long bones of the skeleton, has arrived at the following results for various pygmy races.

	Male.		Female.
Andamanese, 1st series ...	1492	...	1403.
2nd series ...	1476	...	1443.
Bush race, 1st series ...	1444	...	1404.
2nd series ...	1460	...	1420.
Akka dwarfs ...	1200	...	1240.
Aëta ,, ...	1441	...	1384.
Veddah ,, ...	1530	...	1433 (?),

which differ slightly from the results given in the foregoing notes.

Crania. These are small and ovoid, the average capacity being 1120 (2)[1] and the breadth index 69 (2); muscular ridges are not distinctly shewn: as regards prognathism, no direct evidence is forthcoming, but it does not appear that this was a marked feature: in fact the narrowness of the face, which is distinctly cited, tends to shew that these pygmies were not prognathous.

Limb bones and other parts of the skeleton. Only the tibio-femoral (80) and the humero-femoral indices (67·6) can be calculated: no simian affinities are indicated hereby.

The chief characters of importance would seem to be the narrowness of the skull, which distinguishes these pygmies from such existing pygmy races as the Aëta, Semang, Andamanese, or Central African.

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[1] The figures in brackets indicate the number of examples observed.

SECTION D.

PALAEONTOLOGY.

CHAPTER XVII.

FOSSIL PRIMATES.

HAVING concluded enquiries into the Comparative Anatomy, the Embryology, and the Morphological Variations of the Hominidae, it remains to examine the evidence of Palaeontology (the Comparative Anatomy of extinct forms), with a view to ascertaining the bearing of this evidence on the question of the relations of the Hominidae to other Eutheria. As has already been indicated (Chapter I. p. 11), the study of the fossil remains of extinct animals has in certain instances provided most striking evidence as to the evolution of modern forms, and has revealed the former existence of animals which link together groups now separated in appearance and morphological characters. The often-cited example of the Equidae may be mentioned as illustrative of the value of palaeontological research in the former instance, and the discovery of such intermediate forms as Archaeopteryx (which unites Reptiles and Birds), of Arctocyon, possessed of a combination of characters, some of which become intensified on the one hand in the Canidae, others again in the Ursidae of modern times, or of the fossil Lagomorpha, which[1] represent the parent-forms common to modern hares and of squirrels, are illustrative of the value of palaeontology in revealing

[1] Cf. Forsyth-Major, *Linnaean Transactions*, 1895.

links which would have otherwise remained missing had observations been directed to living forms alone.

With such objects in view, it is here appropriate to submit a series of brief descriptions of fossil Primates; at the same time, it must not be forgotten that from *à priori* considerations (cf. Chapter II. p. 26) such forms may be described as "marginal"; that is to say, their characters will not in all instances agree with those conventionally laid down as the necessary qualifications for admission into the Eutherian Order Primates, as constituted in the present geological epoch. With these introductory considerations, we may now proceed to a review of the characters of the following fossil forms.

Sub-order. Lemuroidea :—

I.	Megaladapis.
II.	Adapis.
III.	Anaptomorphus.
IV.	Nesopithecus.

Sub-order. Anthropoidea :—

Family.	Cebidae.	V.	Homunculus.
Family.	Cercopithecidae.	VI.	Oreopithecus.
		VII.	Mesopithecus.
Family.	Simiidae.	VIII.	Pliopithecus.
		IX.	Palaeopithecus.
		X.	Pliohylobates.
		XI.	Dryopithecus.
		XII.	Anthropodus.
Family.	Pithecanthropidae.	XIII.	Pithecanthropus.
Family.	Hominidae.	XIV.	H. primigenius (*seu* neanderthalensis).

FOSSIL LEMUROIDEA.

I. Megaladapis. Gigantic lemurine animals, the remains of which occur in recent (Pleistocene) swamp-deposits in Madagascar. Several species are distinguished: in size they surpassed a St Bernard dog.

The Skull (cf. Fig. 305) bears a general resemblance to those of recent Lemurs, but is much larger and bears much more prominent temporal ridges. The two halves of the mandible are synostosed at the symphysis. From the

examination of a cast of the endocranial cavity, Elliott Smith[1] concludes that
the olfactory bulbs were borne on elongated stalks, and that the disposition
of the cerebral convolutions resembled those of modern Lemuridae.
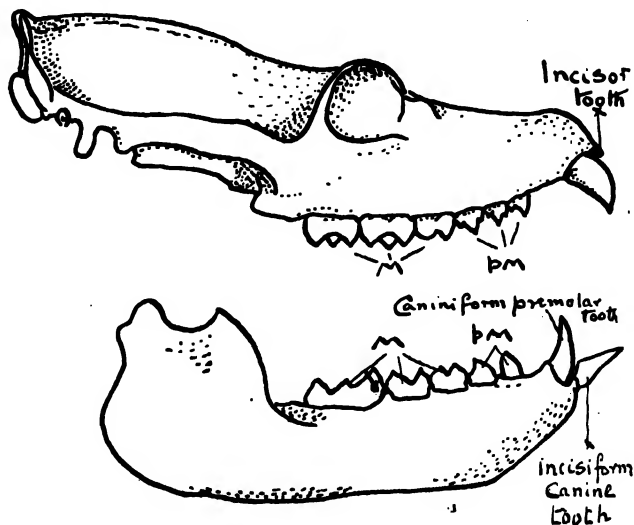
Fig. 305.   Cranium, with mandible, of Megaladapis insignis, a gigantic extinct
Lemur.   The upper incisor teeth are vestigial.

The teeth[2].   It was at one time thought that no upper incisor teeth were
retained in the adult skull: but they seem to be present, though vestigial,
in M. insignis (cf. Fig. 305).   The upper premolar teeth (cf. Fig. 308) bear
external and internal (lingual and labial) cusps.   The upper molar teeth
(cf. Figs. 306 and 309) bear one internal and two external cusps.   In the
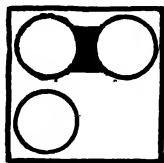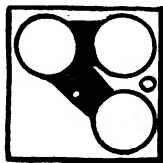
Fig. 306.   Fig. 307.

Fig. 306.   Scheme of cusps of the upper molar teeth of Megaladapis.   The two
anterior cusps are connected by a transverse ridge, leaving the postero-external cusp
isolated.

Fig. 307.   Scheme of cusps of the lower premolar teeth of Megaladapis.   The
antero-external and postero-internal cusps are connected by a ridge.   The third or
intermediate internal cusp is minute in size.

[1] *Cat. Mus. Roy. Coll. of Surgeons*, 1903.
[2] v. Lorenz, *Denk. Akad. Wiss. Wien.* Bd. LXX. 190, Pl. I, Fig. 11.

mandible the last premolar tooth bears one external (labial) and three internal (lingual) cusps (cf. Fig. 307). The molar teeth are provided with two external and three internal cusps, the third tooth of this series being provided with a "talon[1]."
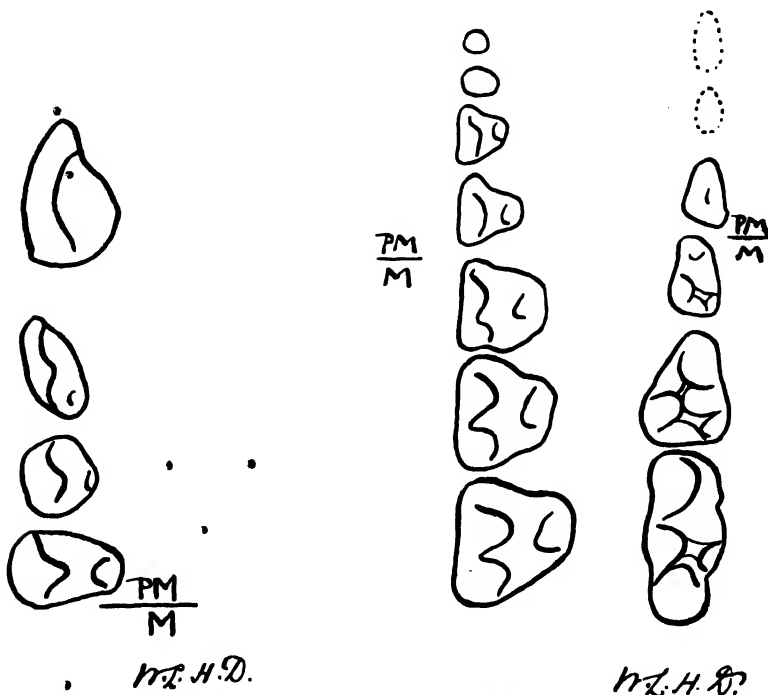
Fig. 308.   Fig. 309.

Fig. 308.   Canine and upper premolar teeth (upper jaw, right side) of an extinct gigantic Lemur, Megaladapis insignis.

Fig. 309.   Teeth of upper (to the left) and lower series of an extinct gigantic Lemur, Megaladapis madagascariensis.

With regard to other parts of the skeleton, the remarkable flattening of the shafts of the humerus, ulna and femur, with flange-like lateral projections, must be noted. Platymeria of the femoral shaft is thus distinct. (Cf. p. 53, footnote; also p. 315.)

Forsyth-Major[2] notes that the femoral shaft is curved, with the concavity

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[1] Specimens of the teeth and skulls of Megaladapis are exhibited in the Natural History Museum, South Kensington. Other specimens are in the Imperial Museum at Vienna.

[2] *Geological Magazine,* Nov. 1900, p. 494.

forwards. In these respects Megaladapis anticipates the characters of the modern Potto (Perodicticus) of West Africa; and since in the latter animals locomotion is sluggish, it is suggested that the Megaladapidae were also thus characterised, and that they were not tree-climbers like most Lemurs of recent times.

II. Adapis. (Cf. Fig. 310 A.) Fossil lemurs found in W. Europe (Eocene strata in France), and in N. America. As an example, the genus known as Hyopsodus may be considered. (The cranium shewn in Fig. 310 A, is that of Adapis parisiensis.) The skull has no post-orbital bar and the lacrymal foramen opens marginally, or within the orbit[1].
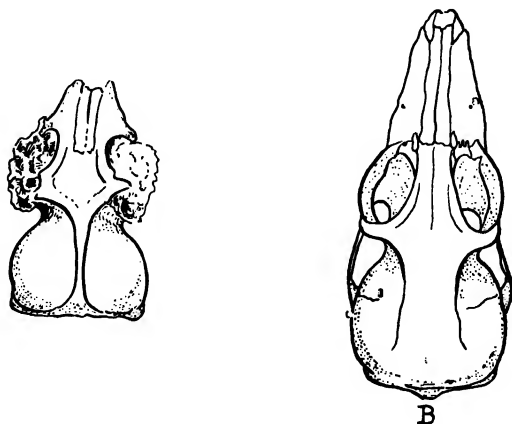
Fig. 310. Crania of (*A*) Adapis parisiensis, a fossil Lemur; and (*B*) Lemur varius, a typical modern Lemur. The crania are closely similar in form. (*Mus. Zool. Cant.* W.L.H.D. del.)

The teeth. The dental formula is extremely primitive (and in fact realises the original formula proposed by Oldfield Thomas as that of the stem-form
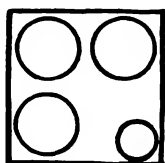
Fig. 311.
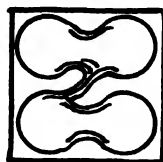
Fig. 312.

Fig. 311. Scheme of the cusps in an upper molar tooth of Hyopsodus. The posterior lingual cusp is the smallest and is inconspicuous in the last upper molar tooth.

Fig. 312. Scheme of the lower molar cusps in Hyopsodus. The oblique ridge connects the antero-internal (lingual) and postero-external (labial) cusp.

[1] Osborn, *Bull. Am. Mus. Nat. Hist.*, Vol. XVI. Art. XVII, p. 179.

of the Mammalia)[1]: 112: i, $\frac{3}{3}$; c,$\frac{1}{1}$; pm, $\frac{4}{4}$; m, $\frac{5}{5}$. In the upper jaw the molar crowns are nearly square, the transverse and antero-posterior diameters being nearly equal. The cusps vary in number, three or four being usually present. (Cf. Fig. 311.)

The lower molar teeth bear four cusps, and these are joined by ridges, disposed as in Fig. 312: a talon is sometimes present.

The incisor teeth are not procumbent as in recent lemurs, but vertical[2] as mentioned above. (Cf. p. 153.)

Of the skeletal parts other than the skull, the humerus is the most important. Forsyth-Major (*Geol. Mag. loc. cit.*) considers that it closely resembles the humerus in the Lemuridae (exception being made in the case of the group known as the Indrisinae).

III. Anaptomorphus. *Family Anaptomorphidae.* The constitution of this Family is based on evidence derived from the study of six mandibles, one of which is accompanied by the skull: the Anaptomorphidae were small lemurine animals, and are noteworthy as occurring in North America, in strata referred to the Eocene period[3].

The position of Anaptomorphus has been the occasion of much discussion, one of the chief points at issue being the question as to whether it is more closely allied to the Lemurs, or to that aberrant Primate-form Tarsius, which, while resembling the Lemurs structurally in many ways, yet is distinguished absolutely from these by its placental form. Judged by the skull, Anaptomorphus is allied to the Lemurs[4]. In the reduplication of the infraorbital foramen, the affinity is with a member of the Cebidae, viz. Chrysothrix. When the characters of the teeth are regarded, Anaptomorphus is considered to resemble Tarsius and the Hominidae, the molars bearing three cusps (tritubercular[5]), except the first and second lower molars; whereas the modern Lemurs and the Adapidae (cf. II. Hyopsodus) are provided with molars bearing four cusps. Osborn gives the dental formula as $\frac{?}{?}$ i ; $\frac{1}{1}$, c ; $\frac{2}{2}$, pm ; $\frac{3}{3}$, m. And in one mandible only two instead of three premolars occur. The skull is very small (only about 20 mm. in length), and superficially resembles that of Tarsius. It is noteworthy that Anaptomorphus closely resembles another fossil Eutherian, viz. Mixodectes, which though at first placed among the Primates, is now considered as rather belonging to the Order Rodentia. We here meet with forms which serve to bridge the gap between two modern Eutherian orders.

[1] *Vide* Chapter vi. p. 150, for a revision of this formula; also Woodward, *Vertebrate Palaeontology*, pp. 404, 406.

[2] Cf. Woodward, *Vertebrate Palaeontology*, p. 405.

[3] Cf. Osborn, *Bulletin of the American Museum of Natural History*, Vol. xvi. Article xvii. 1902, p. 199 *et seq.* Also Hubrecht, *The Descent of the Primates.*

[4] Osborn, *op. cit.* p. 201, characters of the lacrymal bone.

[5] Cf. Chapter vi.

IV. Nesopithecus. This is the generic name given to a number of species found in the fossil state in recent marsh deposits in Madagascar[1]. About four crania and mandibles, more or less imperfect, are known, as well as other skeletal remains. The special claim on our interest possessed by Nesopithecus depends on the conclusion reached by Forsyth-Major, to the effect that the morphological characters confer on this genus a position intermediate between the Lemuroidea and Anthropoidea. Among the groups of characters laid down by Forsyth-Major as a result of his researches on Nesopithecus, the following are the most important.

1. Primitive characters which Nesopithecus shares with Adapis (cf. **II.**) and with certain of the Lemuridae; the cerebellum is not overlapped by the cerebrum; there is a large tympanic bulla; there is no postorbital wall; the lower canine is posterior to the upper caniniform tooth[2], the humerus has an entepicondylar foramen.
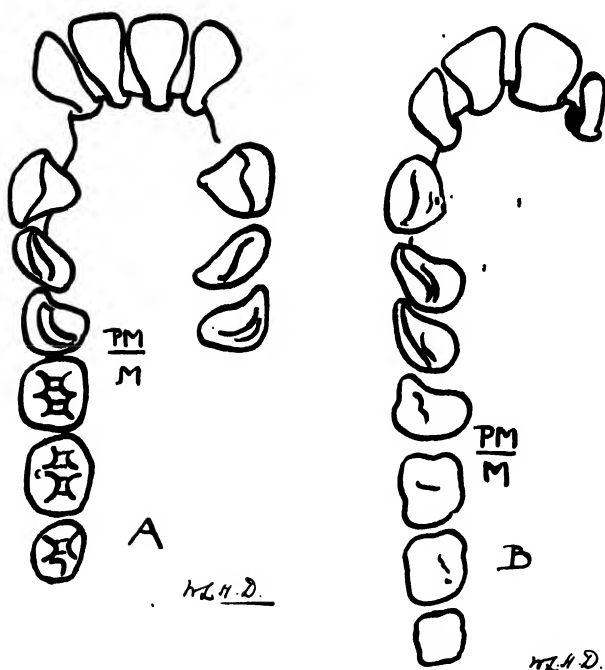
Fig. 313. Teeth (*A*, the upper *B*, the lower series) of Nesopithecus, an extinct primate mammal intermediate between Lemurs and Apes. The lower incisor teeth are spatulate, the molar teeth (except in the last) bear four cusps, and the last molar tooth has but three cusps. The teeth are ape-like rather than lemuroid. The upper molar teeth were probably trituberculax. (From a specimen in the Natural History Museum, South Kensington.)

[1] The specimen first discovered was designated N. roberti.

[2] The exact nature of this tooth is in dispute.

2. Simian characters, not present in Lemuridae, and which Nesopithecus shares exclusively with the Anthropoidea, and particularly with the Cercopithecidae : voluminous brain, with cerebral convolutions arranged similarly to those of Anthropoidea ; "steep" facial profile ; orbits directed forwards ; nasal duct opening within the orbital margin ; conformation of the upper median incisors ; number of the lower incisors. In the *Proceedings of the Linnean Society* (March 5, 1903), Professor Elliott Smith in describing the endocranial cast of Nesopithecus (which is figured in the publication in question) makes the following important remarks : " The shape of the brain and the disposition of its furrows in Nesopithecus are therefore much more pithecoid than those of any other Prosimian (Lemuroid); and in Forsyth-Major's words, it departs from the Lemuridae, and approaches the Cebidae and Cercopithecidae." (*Proc. Roy. Soc.* 1898, Vol. LXII.)

3. The limb bones possess characters intermediate between those of the Lemuridae and Anthropoidea.

4. Characters special to Nesopithecus : these refer to the teeth, the premolars being "blade-shaped." (Cf. Fig. 313, *A* and *B*.)

FOSSIL ANTHROPOIDEA. While fossil Lemuroidea occur in Eocene formations, both in Europe and N. America, the Anthropoidea appear in the Eocene strata of the latter geographical area only ; in Europe they make their appearance only in Miocene deposits, i.e. at an epoch posterior in time to the Eocene. A few forms of Hapalidae and Cebidae are recorded as having been found in Pleistocene deposits in caverns in Brazil, but these are less interesting than the fossils belonging (it is claimed) to the Eocene strata of Patagonia, and described by Ameghino[1]. Four genera have been proposed for these fossil apes of the Family Cebidae : they agree in being of small size, platyrrhine, and in the possession of thirty-six teeth, like the modern Cebidae. (Cf. Chapter III.) Only one genus, viz. Homunculus, will be considered here.

V. *Family Cebidae.* **Homunculus patagonicus.** The mandible is long and very narrow : the premolar teeth are tricuspid, but with one root only : they bear one external, and two internal cusps. The molar teeth are tetra-cuspid, with two external and two internal cusps ; and the first molar is smaller than either the second or the third.

Ameghino has suggested that the occurrence of these Anthropoidea, at such an early epoch as the Eocene period in the New World, gives support to the view that the Hominidae were evolved in that geographical territory. But the suggestion is not strongly supported, and it is a matter of regret that the generic names selected for these Cebian fossils should suggest special human relations which have no great weight of evidence to support them.

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[1] The name of this celebrated palaeontologist should be added to the list of those who dissent from the tritubercular theory of the evolution of the molar teeth in the higher Eutheria. *Vide Ann. Mus. Buenos Ayres*, sér. 2, vol. III. ; reviewed by Lydekker, *Nature*, July 28, 1904.

VI. *Family Cercopithecidae.* **Oreopithecus.** A genus created for animals represented by fossil remains of Miocene age found in Tuscany. The upper molar teeth bear four cusps, viz. two external, and two internal, separated by a sagittally placed furrow (Fig. 314); the cingulum is strongly marked.
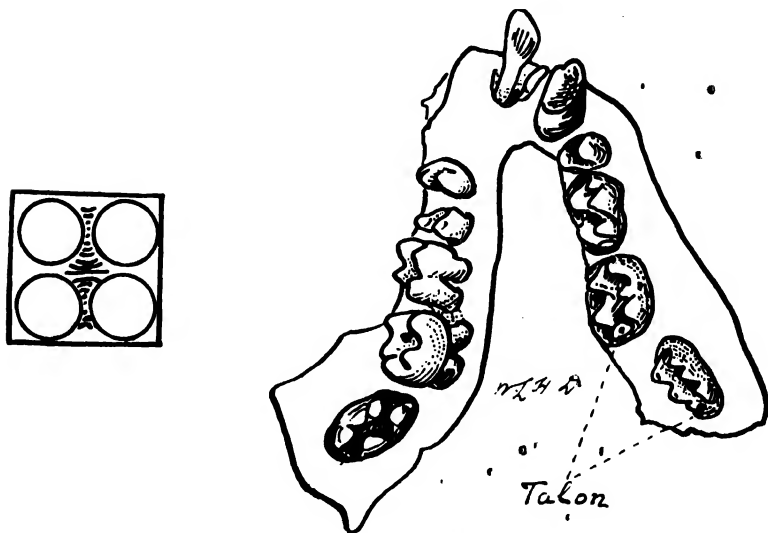
Fig. 314.   Scheme of an upper molar tooth of Oreopithecus: the cusps are four in number, and there is a sagittally-directed groove.
Fig. 315.   Mandible of Oreopithecus bamboli (an extinct monkey from Italy, resembling the Cercopithecidae) : the molar teeth have a distinct " talon'" bearing one or, in the last tooth, two cusps.

The crowns of the lower molars bear five cusps[1], the fifth being posteriorly situated on the backward prolongation or "talon."   (Cf. Fig. 315.)

Oreopithecus bamboli is regarded by some writers as intermediate in characters between the Cercopithecidae and the Simiidae ; Flower and Lydekker regard it as the ancestral form which gave rise to the living Simiidae.

VII. *Family Cercopithecidae.* **Mesopithecus (pentelici).** Numerous specimens, chiefly crania, mandibles, and a few of the stouter long bones, have been obtained in the deposits at Pikermi in Attica.   Gaudry, who first described this species, regarded it as intermediate between the existing genera Cercopithecus and Semnopithecus.   The figures (316, 317 *a*, 317 *b*) represent the skull (from a cast in the University Museum of Zoology) and the teeth

[1] Kramberger (quoted by Klaatsch, *Anat. Hefte*, 1902) has suggested that each molar tooth has been derived, by fusion, from five cone-like teeth. Klaatsch evidently sees difficulties in the way of this hypothesis, for which no strong support is forthcoming.

in a young jaw (from a specimen in the Natural History Museum South Kensington). Better preserved specimens (at Paris) bear transverse ridges like those of modern Cercopithecidae. The femoral shaft was curved with anterior convexity.
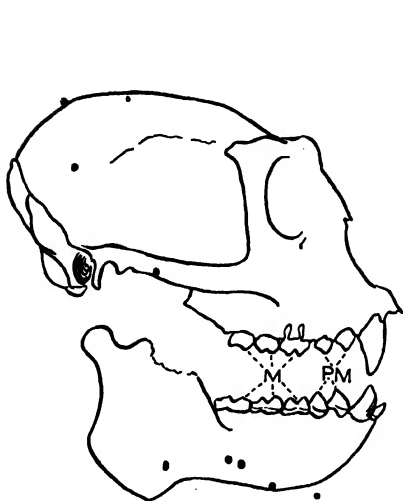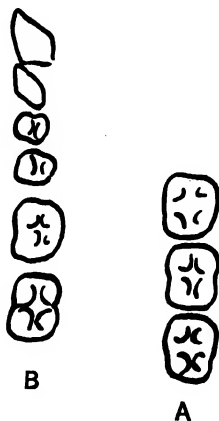
Fig. 316.   Fig. 317.

Fig. 316. Cranium, with mandible, of Mesopithecus pentelici, an extinct European (Greek) monkey. The general characters resemble those of the Cercopithecidae. (Cf. Fig. 28.)

Fig. 317. Teeth of Mesopithecus pentelici; *A*, lower left series (the premolars and molars are shewn; *B*, the upper right series; only the molar teeth are represented.

Family Simiidae.

VIII. Pliopithecus (antiquus). Represented by upper and lower jaws from various Miocene deposits over a wide area of Europe, viz. from the Pyrenees to Styria: the two rows of teeth (premolar and molar series) diverge posteriorly: the molar crowns are narrow and elongated: in the former character Pliopithecus differs from, and in the latter it agrees with, the form known as Dryopithecus, (*v. infra*): on the whole, Pliopithecus is believed to be most closely allied to Hylobates among living Simiidae, and from the latter it is stated by Flower and Lydekker to be indistinguishable. It is however to be noticed that Dubois disputes this[1].

[1] For a critical review of recent literature on the fossil Simiidae, cf. Max Schlosser, *Zoologischer Anzeiger*, Bd. xxiii. No. 616. May 28, 1900: abstracted by W. L. H. Duckworth, *J. A. and P.* Vol. xxxv.

IX.   **Palaeopithecus**[1] **sivalensis.**   Represented by a fragmentary upper jaw from the Sivalik hills, N. Hindustan, in strata of either Miocene or Pliocene age.   Possibly a fossil tooth attributed by Falconer to the Orang-utan, and found in the same deposits, was really referable to Palaeopithecus: but no verification of this suggestion is possible.   Lydekker considered Palaeopithecus to be a Chimpanzee: but Dubois places it lower among the Simiidae, and in fact isolates it on the grounds of the narrowness of the palate and the parallelism of the rows of teeth on either side of the jaw.

The molar teeth (Fig. 318) have no crenate markings: but this would separate Palaeopithecus from Anthropopithecus (Chimpanzee) almost as effectually as from Simia (Orang-utan) among living Simiidae. The narrowness of the palate has already been remarked: it is narrower than in any anthropoid except Gorilla and Dryopithecus, and the molar teeth are said to be very human in appearance.   Flower and Lydekker state that "all essential characters of Anthropopithecus (Chimpanzee) are present: the two series of cheek teeth have a slight anterior convergence[2];" the premolars are shorter in sagittal diameter, and the lateral incisors are narrower than in Anthropopithecus.

X.   **Pliohylobates**[3] **(eppelsheimensis).**   This species is based on (a) the characters of a single femur, found in strata of Miocene age in the Rhine-valley at Eppelsheim, near Darmstadt, and (b) portions
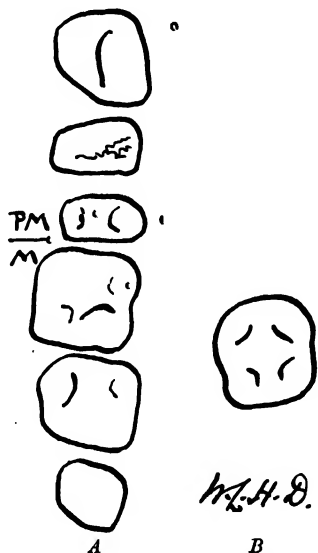
Fig. 318.   Teeth of Troglodytes sivalensis, an extinct anthropoid ape (Simiidae); A, upper right series; the molar teeth were probably four-cusped; the last tooth is degenerate in point of size.   B, second left upper molar tooth.

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[1] Or, *Troglodytes.*

[2] This does not agree with Dubois'.view.

[3] Or Pajdopithex; cf. Pohlig, *Bull. Soc. Belg. Géol.* Vol. ix. 1895, p. 149, Figs. 1 and 2: also Kaup, *Beitr. zur Säug.* 1861, Heft 5, Fig. 1.

of three mandibles, found in France and Germany respectively. The former specimen has been the cause of much discussion, and inasmuch as it was discovered some sixty years ago, it has attracted the attention of a considerable number of authorities. The following notes will give an indication of the opinions that have been put forward concerning its affinities.

(1)   It has been ascribed to a human being (a young female).

(2)   It has been regarded as belonging to an ape of the same species as yielded a fossil humerus found at S. Gaudens in France; the latter form was described as a fossil Hylobates (Gibbon) by Owen, under the name of Dryopithecus fontani.

(3)   It was then pointed out, (a) that the strata at S. Gaudens are not of the same geological age as those of Eppelsheim, (b) that the argument from femur to humerus was not a very safe one, and (c) that therefore judgment must be suspended before identifying the fossil apes of S. Gaudens and of Eppelsheim.

(4)   It might be a femur of Pliopithecus (q.v.), but of the latter only the maxillae are known.

(5)   Dubois separates the possessor of the Eppelsheim femur from all the foregoing, and describes it, under the title Pliohylobates, as an ancestral form of Gibbon. The length of the bone (284 mm.) is too small for a human femur: the presence of a linea aspera, though a human feature, does not exclude the possibility of its being that of a Gibbon, and Dubois concludes that Pliohylobates exceeded by ⅛ the bulk of the largest existing form of Gibbon.

The mandible and teeth resemble those of existing Gibbons.

XI.   Dryopithecus (fontani).   Represented by about four mandibles and a humerus, from strata of Miocene age (but not contemporary with the Miocene of Eppelsheim) at S. Gaudens in France.

The molar teeth, Fig. 319, bear crenations on their crowns not unlike those of the molar teeth of Orang-utan and Chimpanzee. Flower and Lydekker state that the mandibles resemble those of Gorilla, inasmuch as the two lower molar series of teeth diverge anteriorly, while the first premolar exceeds the second in size: on the other hand, the mandibles differ from those of the existing Simiidae, in the possession of a long and narrow symphysis, this being a character by which they are approximated to the Cercopithecidae.

It is to be noted that the characters of the first mandible found
led to the conclusion that Dryopithecus was an anthropoid ape
more highly evolved than any of the existing Simiidae, and thus
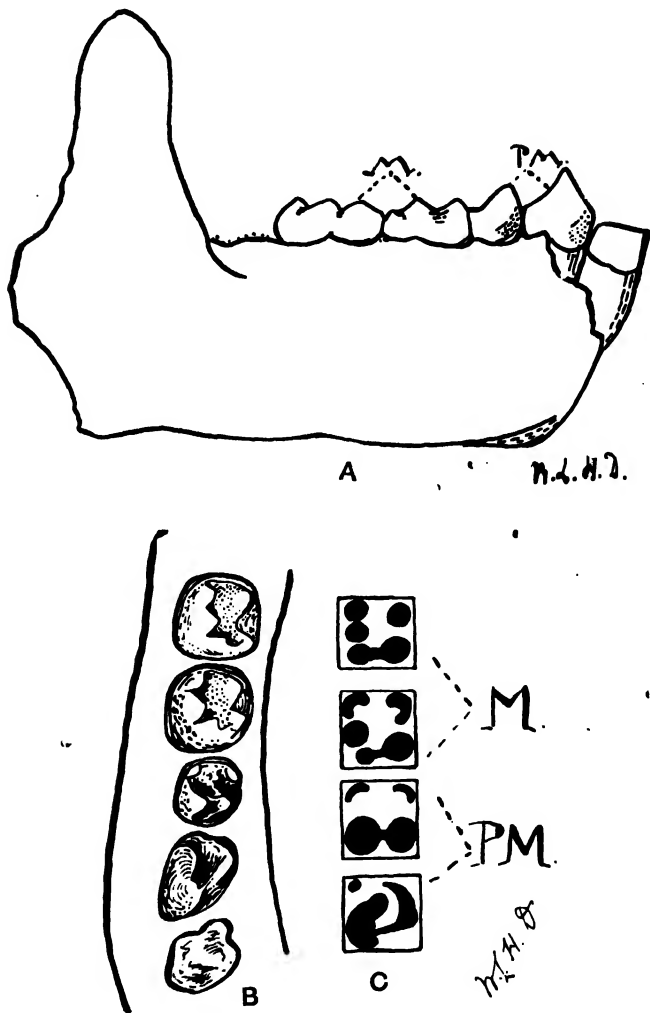
Fig. 319. Mandible (*A*) and teeth (*B* and *C*), of Dryopithecus fontani, an extinct
anthropoid ape resembling the Chimpanzee (Simiidae). *C* represents diagram-
matically the number and disposition of the dental cusps: the transverse ridges
resemble those prevalent in the Cercopithecidae.

one of the links between the Simiidae and Hominidae[1]: but the discovery of other mandibles did not support this view, appeals being made principally to the characters of the molar teeth (i.e. the proportions of sagittal and transverse diameter; and the incurving of the external posterior cusps). Judged by the form of the molar teeth, Schlosser would derive the modern Orang-utan and Chimpanzee from Dryopithecus, which is thus regarded as ancestral to these, but not to Gorilla or the Hominidae.

On the other hand, Flower and Lydekker suggest that the transition has been from Dryopithecus to Gorilla, Anthropopithecus and the Hominidae in succession. Pohlig gives the succession as Orang-utan, Chimpanzee (and Gorilla), Dryopithecus, Homo: and against this we find 'Gaudry postulating the sequence as Dryopithecus, Gorilla, Orang-utan (with Gibbon and Pliopithecus), Chimpanzee, Homo. From the characters of the mandible and humerus (the latter had not retained its terminal epiphyses), an attempt was made to decide as to whether Dryopithecus was more like the Gibbons, or whether its length of arm was less than in these. The humeral length, in comparison with the length of the dentary arcade, is too short for the proportions to resemble those of modern Gibbons.

It must be admitted that judgment is not easy to pronounce at present, and the recent discovery of certain teeth in the Bohnerz ore in S. Germany[2] renders a decision even harder than before, for the latter teeth, though attributed to Dryopithecus, admittedly resemble human teeth very closely, and but for their occurrence in Miocene strata would probably have passed as of human origin. Two new species of extinct anthropomorphous apes are based upon the characters of molar teeth found in the calcareous Leitha formation in Austria (Vienna). To these forms the names Griphopithecus suessi and Dryopithecus darwini have been given by Abel[3]. The characters of these teeth present the same difficulty of identification as is provided by the fossils previously described.

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[1] Gaudry, quoted by Schlosser, *Zool. Anz.* No. 616, p. 297.

[2] Cf. v. Branco, *Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg*, 1898.

[3] *Centralbl. fur Mineral. Geol.* etc. 1903.

XII.   **Anthropodus brancoi.**   In view of this difficulty
Schlosser[1] has created a new genus and species for the reception
of the possessor of the teeth from the Bohnerz; this is now
distinguished as "Anthropodus brancoi." It must be remarked,
nevertheless, that while Schlosser recognises the close affinity of
Anthropodus (brancoi) with Dryopithecus (fontani), and the further
close resemblance to the Hominidae, he comes to no definite con-
clusion as to the genetic relationship of Anthropodus and the
Hominidae[2]. (Cf. Schlosser, *Zool. Anz.* 616, p. 264.)

XIII.   **Family Pithecanthropidae.   Pithecanthropus (erec-
tus).**   This genus is represented by a single individual, skeletal
portions of which were discovered in strata referred to the Pliocene
series, in Java at Trinil, by Eugène Dubois of Amsterdam in
1892–4.   The announcement of this discovery and the conclu-
sions as to the nature of the fossil form, which have been based
on the study of the remains in question, have aroused a storm of
controversy, in the course of which the most diverse opinions have
been expressed.   Incidentally, too, the controversy has been the
means of stimulating some admirable researches in physical an-
thropology[3].   Dubois published his first descriptions at Batavia in

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[1] *Zoologischen Anzeiger*, Band XXIV. No. 643.

[2] Gaudry notes (*Comptes Rendus: Congrès d'Anthropologie et d'Arch. préhist.*
1900, p. 39) the general tendency in the palaeontological series to a transition
from the tricuspid to the quadricuspid type of upper molar tooth.   This tendency
is noticeable in several orders of Mammalia, and the Hominidae have now reached
a stage attained by many of these in the early Tertiary epoch.   The quadricuspid
type of molar tooth has not been perfectly acquired, inasmuch as the postero-
internal cusp it still feeble and indistinct.   This indistinctness is chiefly character-
istic of the European white races, for the cusp in question is more prominent in the
negro races, and also in Anthropopithecus and Hylobates (though in Simia there is
again indistinctness).   Passing back to fossil Simiidae and Cercopithecidae, in
Dryopithecus and Oreopithecus the cusp is still more evident.   Two hypotheses are
thus open : (*a*) that in the white races, this molar tooth is degenerating from a
stage of development which reached its highest point in the Dryopithecus phase of
human ancestry ; or (*b*) that the white Hominidae have not advanced in the evolution
of the upper molar teeth beyond the stage reached by their forerunners in the earlier
Tertiary period (Eocene).   While the author does not suggest which of these
hypotheses is the more worthy of adoption, the balance of evidence favours (*a*), so
that we may conclude that degeneration has set in, and indeed it is not difficult to
find evidence of the continued activity of this process.

[3] The literature is now very extensive.   Dubois published several supplementary
memoirs in the years 1895–1900; the pages of the *Archiv für Anthropologie,*

Java in 1894. Fossil remains of the Primates are sufficiently rare to attract a certain amount of attention independently of their exact relation to the Hominidae. But the interest here aroused was unusually intense, inasmuch as Dubois claimed for the Trinil fossil, a position intermediate between the Simiidae and Hominidae, i.e. the position of a link hitherto missing in human ancestry—the pithecoid ancestor postulated by Lamarck, Darwin, and Huxley —thê Homo alalus of Haeckel.

Current opinions formed subsequently to inspection of the actual fossils, are divisible into three main classes, which are represented by almost equal numbers (and curiously enough, in two of the three cases, the authorities are distinguished in nationality as well as in opinion). First, then, come those who following the lead of Dubois, consider that a human ancestor, not yet wholly human, and yet superior to the Simiidae, is represented by these Javan remains. Secondly, come a number of human anatomists, including most of the leaders in that subject in England, who have recorded their testimony in favour of the truly human nature of the Trinil fossil. Thirdly, come those (for the most part German observers[1]) who believe that the Pithecanthropus erectus was a large Hylobates, and as such, a member of the Simiidae; for these authorities, the remains are neither[2] those of an intermediate form, nor of a human being, but of a veritable ape.

Zeitschrift für Ethnologie, Bulletins de la Société d'Anthropologie de Paris, Anatomischer Anzeiger, and the *Journal of Anatomy and Physiology* for the year 1895, will supply the most important references. Most important communications on the subject also appeared in Schwalbe's *Zeitschrift für Morphologie und Anthropologie* 1899, *et seq.*

[1] It must be noticed that in Germany there are anatomists of the first rank, e.g. Schwalbe and his pupil Klaatsch, who have adopted and confirmed the view of Dubois.

[2] The following list (which is not complete) shews the composition of the foregoing groups:

I. Adopt the view that Pithecanthropus erectus is an intermediate form. Dubois, Manouvrier, Marsh, Haeckel, Schwalbe. Klaatsch, so far as I understand his opinion, regards Pithecanthropus erectus as an intermediate form, but not as ancestral to Man.

II. Adopt the view that Pithecanthropus erectus is to be regarded as truly human. Turner, Cunningham, Keith, Lydekker, Martin.

III. Adopt the view that Pithecanthropus erectus is to be regarded as purely simian. Virchow, Krause (for the calvaria), Waldeyer, Ranke, Bumüller.

Incidentally it is interesting to note that several of those who adopt the view of the human nature of this fossil animal, qualify their belief by admitting that it is far inferior to any known human form, whether fossil or recent. And, conversely, those who believe that we have here to do with an ape, in turn concede that this was morphologically superior to any known member of the Simiidae, whether extinct or still existing. A better illustration of the difficulties of defining in detail an animal-form, when the criteria are limited, could scarcely have been selected, and the lines which demarcate the several opinions just mentioned, are seen to be excessively finely drawn. The opinion has been expressed that the remains are those of a human idiot of the type known as "microcephalic[1]," but besides the consideration that the chances of the preservation of such an individual in a fossil state are infinitely small, the characters of the bones do not support this view. To the study of those characters it is now time to turn.

The remains consist of: first a calvaria, or upper portion of a cranium; secondly a (left) femur; thirdly, three teeth, viz. the second and third upper molars, and the lower second premolar of the left side. The order here observed is not that in which the remains were discovered, and the discoveries were made at various epochs separated by months and even years, for the last mentioned tooth was found long after the other remains. For details of the circumstances attendant on the actual discoveries, reference should be made to the original publication. Here we are concerned to review the principle features of the several specimens: and these will be considered in the order given above.

THE CALVARIA (Figs. 320 and 321). This is the upper portion of a skull of large proportions: in extreme length it measures 185 mm., in breadth 130 mm., and consequently its breadth index is 70 (approximately). The index of height is much lower, the small vertical height of the calvaria being a very distinctive feature. The bones of the vault have all been united, synostosis having obliterated the sutural lines completely, and though there is no such sharp median sagittal ridge (as in the crania of adult male

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[1] Cf. pp. 448—450.

Simiidáe of the larger genera), yet in the frontal region the skull vault is slightly keeled, reproducing locally the condition known as scaphocephalus[1].
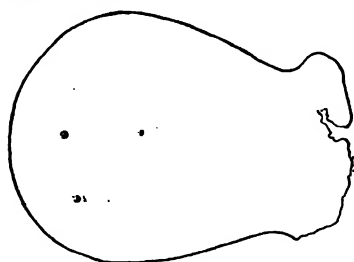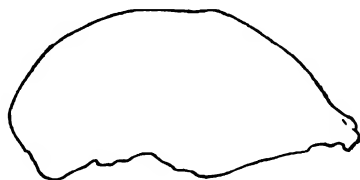
Fig. 320.   Fig. 321.

Fig. 320.   The calvaria of Pithecanthropus erectus seen from above (⅓ nat. size).

Fig. 321.   The calvaria of Pithecanthropus erectus seen from the side (⅓ nat. size).

The brow-ridges of the Trinil calvaria are massive[2], and posteriorly to them the diameter of the skull is relatively small, so that the appearance of post-orbital "compression" is very marked. Such "compression" should rather be termed arrested growth, and the appearance is very characteristic of the larger Simiidae, in which the jaw is very ponderous, and the mass of temporal muscle that has to be accommodated in the temporal fossa is very great. No very prominent ridges traverse the surface of the calvaria, whether on the upper or on the nuchal aspect; the latter part is nearly complete, and the posterior margin of the foramen magnum can still be recognised. This posterior or occipital surface slopes forward, with relatively little obliquity, and this portion of the skull is attenuated in development as compared with the corresponding portion of a human cranium. At the same time, there is a slight but distinct indication of that bulging of the occipital bone found in many

[1] Such a condition is said to characterize human crania in which the synostosis of the two halves of the frontal bone has been premature ; the transverse growth of such human crania is often arrested with the production of an abnormal skull-form called Trigonocephalus.

[2] Comparison is naturally suggested with the heavy-browed scaphoid and prognathous skulls of certain aborigines of Oceania and of Australia. But these human crania differ from that of Pithecanthropus erectus in the much bolder curve of the sagittal arc, and the greater rotundity of the occipital region.

dolichocephalic human crania. This bulging, to which the term "renflement occipital" has been applied by French writers, may be indicative of the presence of a well-marked sulcus lunatus in the cerebral hemispheres covered by such crania[1].

Considering (for the moment) the calvaria on its own merits, we shall notice that there are several strongly marked simian features. Such for instance are:

(1)   The completeness of synostosis of the component bones of the cranium.

(2)   The massive brow-ridges.

(3)   The post-orbital compression.

(4)   The low flattened curve of the sagittal arc of the cranium.
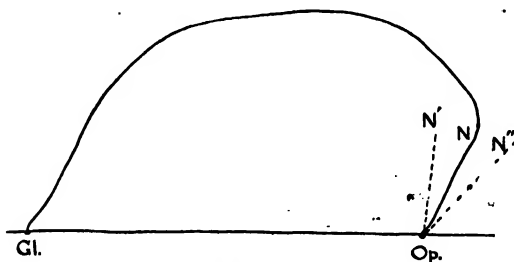
Fig. 322.   Tracing of the calvaria of Pithecanthropus erectus, to shew the angle included by the nuchal plane (N), and the Glabello-opisthionic line (Gl–Op).   N′ represents the inclination of the nuchal plane in Hylobates (Simiidae), and N″ the corresponding inclination in a Papuan skull (Hominidae): the latter specimens were orientated similarly, i.e. with the glabello-opisthionic line corresponding in position to the calvaria of Pithecanthropus erectus.

Against these are to be placed the following items which differentiate the calvaria from those of the Simiidae, approximating it to those of the Hominidae.

(1)   The great absolute size and capacity: the latter is estimated at 855 c.c., and is thus greater by about 250 c.c. (or over 30 %) than the corresponding figure for the largest skull of the Simiidae.

(2)   The associated brain-weight, estimated at 750 gm.

(3)   The distinctness of the third frontal convolution. This argument urged by Dubois must however be largely discounted in view of the researches of Cunningham and Elliott Smith on the development of this convolution in the Simiidae.   (Cf. p. 451.)

[1] Cf. Elliott Smith, *Rep. Brit. Ass.* 1904.

(4) The situation of the line of maximum diameter of the calvaria, i.e. more anterior than in the Simiidae, and thus agreeing fully with the condition in the Hominidae.

(5) The angle of the nuchal plane (see Fig. 322): in this respect, the Javan fossil is truly intermediate between the Simiidae and the Hominidae.

THE FEMUR. From the calvaria we may turn to the consideration of the femur (cf. Fig. 323), which, as already said, is that of the left side. The bone bears a striking anomaly, in the form of an exostosis, of considerable size, springing from the region of the linea aspera in the upper third of the shaft. The exostosis, which is pathological in nature, has formed the subject of a good deal of discussion, as the net result of which, it seems that the bearing of this feature is absolutely *nil* as regards the determination of the real nature of Pithecanthropus erectus. In size and in its general features the femur is so human, that Dubois himself admits that had it not been associated with the calvaria, the femur would have been regarded by him as that of a man[1].
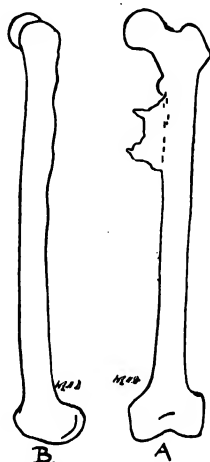
Fig. 323. Two views of the left femur of Pithecanthropus erectus.

The shaft of the femur is remarkably straight, though not absolutely so. This feature might be thought to establish a point in favour of referring the bone to a member of the Hominidae. But observation, stimulated by the interest of the research, shewed (a) that the shaft of the bone in mankind may be quite appreciably curved (with the convexity of the curve directed forwards), without modifying the erect attitude of the individual; and (b) that in the (arboreal) Hylobatidae among the Simiidae, the femoral shaft may be distinctly straighter than in the (terrestrial) Hominidae.

In the femur we must therefore recognise certain features as simian, and according to Dubois and others, some of these are distinctly approximate to the conditions in Hylobates, viz.:

[1] In this case, the existence of Man in the Tertiary epoch (Pliocene) would be established.

(1) The straightness of the shaft.

(2) The fulness of the bone on the inner side of the shaft: this is associated with a lack of prominence of the linea aspera.

(3) The fulness and convexity of the shaft at its lower end in the popliteal space, so that instead of the flattened area seen in the vast majority of human femora, there is seen a bulging, which is excessively rare in the Hominidae; and the resulting index of platymeria provides the very high (numerical) value of 97.

(4) The feebleness of the inter-trochanteric line.

(5) The position of the adductor tubercle on the inner aspect of the internal condyle at the lower end of the bone, as judged by the "Bandradien" index[1] the femur is simian rather than human.

Against the foregoing simian characters, may be set the following human features:

(1) The absolute length, which is given as 455 mm. (with an associated stature of 1650 to 1700 mm.).

(2) The slenderness of the shaft.

(3) The presence of a distinct linea aspera.

(4) The size of the head of the bone.

(5) The length of the femoral neck.

Finally it must not be forgotten that some of the characters in the first list are not beyond the range of variation of undoubted human femora.

THE TEETH. The teeth consist of two upper molars and one lower premolar. Of the former, one is from the left side of which it is the second tooth, while the other (Fig. 324) is a third upper right molar[2]. The principal characters of these two teeth are as follows[3]:

Fig. 324. The last upper right molar tooth of Pithecanthropus erectus. Degeneracy is denoted by crenation and comparative reduction of the antero-posterior diameter of the crown, which is markedly inferior to the transverse diameter.

(1) The roots are strong-

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[1] Cf. Bumüller, *Das menschliche femur*, p. 131.

[2] Amoüdo, quoted by Kükenthal, *Jahresber. der Anatomie* (1902), considered this to be a first molar tooth.

[3] Dubois, *Anatomischer Anzeiger*, Band XII. 1896, p. 16.

ly divergent, and thus the teeth are clearly distinguished from modern human teeth.

(2)　The dimensions of the crowns exceed those of any human races, save certain macrodont negroes of Oceania or aboriginal natives of Australia. The figures provided by Dubois are compared in the accompanying table with other data, some of which (for the Gorilla and Orang-utan) are based on measurements of specimens in the Cambridge Anatomy School.

(a)　Third upper molar tooth :	Sagittal diameter	Transverse diameter
Pithecanthropus erectus	11·3 mm.	15·3　mm.
Australian aboriginal (Virchow)	10·5　,,	15·0　,,
Average from five Gorillas	15·6　,,	16·25　,,
,,　　,,　　six Orang-utans	13　　..	14·1　..

In this tooth, reduction of the sagittal diameter as compared with the transverse diameter is marked; this is a feature which approximates Pithecanthropus erectus to the Hominidae, and separates it from the Simiidae.

(b)　Second left upper molar tooth :	Sagittal diameter	Transverse diameter
Pithecanthropus erectus	12·0 mm.	14·0 mm.
Australian aboriginal (Virchow)	12·5　,,	15·5　,,
Gorilla (average of five examples)	16·2　,,	16·0　,,
Orang-utan (average of six examples)	12·9　,,	15·0　,,

The third molar tooth will be seen in comparison to be degenerate in point of size. This degeneration has commenced even in Gorilla, and reaches its maximum in the Hominidae.

(3)　The postero-internal inner cusp is in each of these teeth distinctly the smallest and is therefore degenerate: in the Simiidae the postero-external cusp is said to become reduced before the postero-internal cusp is affected. But as a matter of fact, the crown of the third upper molar tooth of Pithecanthropus erectus (cf. Fig. 324), is clearly degenerate, and even the other cusps are but vaguely marked; there is a certain amount of crenation, which would have probably in any case obscured the lines of distinction of the several cusps. Keith suggests in fact that the tooth is actually that of an Orang-utan.

(4)　The roots of these molar teeth are large and very strongly divergent. This is a simian, and not a human feature.

(5)　The proportion of the transverse diameter of the crown of the second molar tooth, to the maximum transverse diameter of the calvaria, is identical with the proportion yielded by a female Hylobates skull measured by Dubois: this proportion is in male Hylobatidae greater, and in the Hominidae less, than in Pithecanthropus erectus.

(6)　I have not been able to find a description of the lower premolar tooth, but in conversation, Dubois mentioned that in the lack of incurvation of the inner cusp, it resembles the corresponding tooth of the Hominidae.

To sum up the characters of these teeth, it will be seen that while distinguished from human teeth by the large dimensions of the crown and roots, and by the strong divergence of the latter, they nevertheless differ from the teeth of any member of the Simiidae.

Having now considered the several specimens apart, it remains to consider the outcome of their association in a single individual. We may, by way of recapitulation, repeat that the characters of the calvaria and teeth are on the whole intermediate between those of the Simiidae and the Hominidae, while the balance of evidence, as regards the femur, tends (*pace* Dr Bumüller) to shew that it is quite possibly human. From the characters of these remains, we must picture Pithecanthropus as an animal of considerable size (for the femur indicates a stature of about 1650 to 1700 mm.) with a corresponding body-weight of about 70 kilogms. So bulky an animal must have been largely terrestrial in habitat, and if terrestrial, had probably assumed the erect attitude. The great brow-ridges of the calvaria, and the large teeth, shew that the jaws were larger than in any of the Hominidae, and probably not very different in proportionate bulk from those of the existing Hylobates (cf. Fig. 70). But the cranial capacity indicates the possession of a brain weighing about 750 gm. The question must now be asked, Does this amount of brain-substance, taken in relation with the body-weight, provide the correct proportion for a man, or for an ape, or for neither? Now quite apart from the detailed consideration of brain-weight as an index of intellectual capacity, the very high ratio of brain-weight to body-weight is characteristic of the Hominidae (taken *en bloc*).

From the weights of brains recorded by Max Weber and others, Dubois has made a careful investigation into the proportion of brain-weight to body-weight in a series of animal forms, and the foregoing statement is one of the results of that enquiry[1]. The ratio of brain-weight to body-weight may be called the cephalisation of the particular animal.   (Cf. p. 403.)

If now we start with the value of the brain-weight of Pithecanthropus erectus[2], and calculate the corresponding body-weight on the assumption (of Turner, Cunningham and other anatomists) that Pithecanthropus erectus was human, we find from the data provided by Dubois that this body-weight should be about 19 kilogms.   This result must be checked by a comparison of the value for the body-weight, inferred from the stature, the latter value being in turn given by the femoral length.   The length of the femur shews that the body-weight was about 70 kilogms.   The great discrepancy in these results leads to the inference that Pithecanthropus erectus was probably not human.

If next, in company with Waldeyer, Ranke, Bumüller and others we assume that the relations of Pithecanthropus erectus are with the Simiidae and not with the Hominidae, we shall find (still using the data provided by Dubois) that the appropriate body-weight for an ape with a brain weighing 750 gms. is nearly 230 kilogms., whereas actually the femoral length of Pithecanthropus erectus will not provide a greater bulk than 70 kilogms. The discrepancy is even greater than before, and 230 kilogms. is an enormous weight for a Primate Mammal: we therefore conclude that the simian nature of Pithecanthropus erectus is not proven.

The final researches of Dubois, carried on from this point, shew that not only are we caught in a dilemma as just shewn, whether we assume that Pithecanthropus erectus is human or simian, but also on the positive side, the comparison of brain-weight and body-weight in Pithecanthropus erectus leads to the conclusion that the cephalisation is but half that of the Hominidae and nearly twice that of the Simiidae.   Such a demonstration of the truly inter-

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[1] Cf. Dubois, *Archiv. für Anthropologie*, Band xxv: *Die Abhängigkeit des Hirngewichtes von der Körpergrösse*: also Dubois, *Proc. Int. Cong. Zoology*, Cambridge 1898.

[2] The brain-weight is estimated by means of the value of the cranial capacity.

mediate position of Pithecanthropus erectus is all but complete, for the only positions left to those who do not accept this conclusion, are (*a*) that Pithecanthropus erectus was a human microcephalic idiot, of the type in which the amount of brain substance is very materially reduced. In this connection it must be repeated that the chances are very much against the preservation of the remains of such an idiot since the Pliocene period : and secondly, that such individuals rarely survive to maturity and are even then usually stunted in growth, whereas the Trinil fossil was of stature rather over the average : (*b*) that Pithecanthropus erectus was an anthropoid ape of a degree of cephalisation far superior to any ape now existing. But the latter fact would of itself remove the Trinil fossil from the Simiidae, and would place it exactly in the intermediate position claimed for it by its discoverer.

This claim must, in my opinion, be considered as justified. As I have elsewhere stated[1], I believe that in Pithecanthropus erectus we possess the nearest likeness yet found of the human ancestor, at a stage immediately antecedent to the definitely human phase, and yet at the same time in advance of the simian stage.

Family Hominidae.

XIV. **Homo primigenius** (*seu* **neanderthalensis**). With Pithecanthropus erectus, we pass the gap which separates the Simiidae from the Hominidae. This passage is moreover effected independently of the view adopted as to the precise morphological status of the fossil Primate discovered by Dubois. Those remains, as we have just seen, were found in strata referred, on geological considerations, to the Pliocene epoch, i.e. to the later stages of the Tertiary period.

The exact geological horizon upon which the Hominidae make their earliest appearance is still unknown, though surmise and speculation have long been rife upon this subject. Incidentally we may remark that materials for the solution of the problem are supplied, not only by the fossil remains of Man, but also by implements, the work of human hands. Actually, it cannot be

[1] *Journ. A. and P.* Vol. **xxxv**.

stated with confidence that the Hominidae existed even in the latest phases of the Tertiary period, even with the extension of evidence thus provided. For years past announcements have at intervals been made of the discovery of human artefacts of undoubted tertiary age : and hitherto in no case has the evidence been sufficiently strong to ensure general recognition of the claim advanced[1]. While the existence of Man in the Tertiary epoch must remain for the moment uncertain, there can be no doubt as to the early appearance of Man in what is known as the Diluvial period.

It is a remarkable fact that among the human crania for which great antiquity has been claimed, much diversity of form obtains[2]. This might indicate that the several varieties in question were evolved simultaneously with the human form, or that the claims put forward for the extreme age of the specimens are false. These possibilities demand the very closest investigation, and it must be remembered that the process of evolution is in some instances very rapid. If so in this case, the co-existence of round and long skulls at an early epoch in human evolution would be comprehensible though perhaps not easily explicable ; as it is, Palaeontology has not yet provided definite evidence of the possession by primitive man of one type of skull to the exclusion of others, though among the individuals of acknowledged antiquity, the long-heads are in a majority.

Apart from the single characteristic of the proportions of the brain-case, several other anatomical features are found to be so combined in certain fossil crania, as to confer upon these a distinctly lower status than that of any of the existing races (even the aboriginal races of Australia not excepted). The individuals thus characterised are associated in a group specifically distinct from the modern Hominidae, to which the name Homo primigenius or Homo neanderthalensis, has been applied. But so far as I can judge, four individuals only seem to be endowed with the qualifications requisite for such independence. It must remain a matter for discussion whether these are to be regarded as

[1] Geikie, *Text Book of Geology*, 1903, points out the difficulty that is met with in determining the precise age of flint implements, and therefore the claim to antiquity of the so-called "eolithic" specimens cannot be yet unreservedly accepted.

[2] This fact to some extent militates against the view expressed on p. 456 *supra*.

individual cases of reversion, or as examples of a species of Hominidae now extinct. From an examination of the evidence, I consider that the latter view is justified and shall therefore refer to this variety as specifically distinct, under the title just mentioned (viz. H. primigenius, *seu* neanderthalensis).

H. primigenius is represented by the following examples: (*a*) the portions of the skeleton[1] discovered in 1856 by Fuhlrott in the valley of the Neander (near Düsseldorf); (*b*), the crania, with other portions of the skeleton[2], discovered in 1885 at Spy in Belgium, by de Puydt and Lohest; (*c*) the fragmentary remains of several skeletons (from which part of one calvaria[3] has so far been reconstructed) found at Krapina in Croatia, by Kramberger.

(4)   The actual remains comprise the following parts:—

(*a*)   The skeleton from the Neanderthal, Germany. These remains, which are now in the Antiquarian Museum at Bonn, comprise the calvaria, the two femora, the right humerus complete, the lower two-thirds of the left humerus, the left ulna complete, the proximal half of the right ulna, the right radius complete, part of the left os innominatum (ilium), part of the right scapula, the right clavicle and some fragments of ribs.

(*b*)   The Spy specimens consist of portions of two skeletons, assigned with some doubt to male and female individuals respectively. Of the skulls, rather more than the calvaria remains in each case, and fragments of the mandibles with the teeth still *in situ* were also discovered.

(*c*)   The Krapina fragments comprise remnants of about ten skeletons. The crania are fragmentary. Many teeth were found (the total number amounting to 115).

Such classical examples as the crania from Canstatt[4], Egisheim[5],

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[1] Fuhlrott, *Verhand. der naturahist. Vereins der preuss. Rheinlandes und Westfalens*, 1857: quoted by Schwalbe, *Der Neanderthalschädel, Bonner Jahrbücher*, Heft 160, 1901. The Neanderthal skeleton has given a name to the species.

[2] Fraipont et Lohest, *Archives de Biologie*, Tome VII.

[3] Gorjanović-Kramberger, *Mitt. der Wien. anth. Ges.* XXXI. Band, pp. 164—197; XXXII. Band, pp. 189 et seq.

[4] Spleiss (stated by Fraipont and Lohest not to have recognised the human nature of the specimen) in *Dissertatio Historico-physica de cornibus et ossibus fossilibus Canstadiensibus*, 1701.

[5] Faudel, *Bull. Soc. hist. nat. de Colmar*, 1867.

Gibralter[1] (Forbes Quarry), Hungary (Shipka)[2], Galley Hill in Kent[3] Tilbury[4], Engis in Belgium[5]; from Abbeville[6], Chancelade[7], Dénise[8], Cro-Magnon[9], and other localities in France; and from Brüx in Bohemia[10] with many others[11], are thus excluded from morphological association with the foregoing more lowly examples[12]. Schwalbe[13] has recently modified this classification, and groups the Neanderthal, Spy, Krapina, La Naulette[14], Arcy[15], Malarnaud[16], Shipka, and Taubach[17] remains together as those of Homo primigenius, and distinguishes these from palaeolithic remains of Homo sapiens, to which he refers the Egisheim, Tilbury, Denise, Brünn[18], Predmost[19] and a few other fossil examples. Attention

[1] Broca, *Bull. Soc. d'Anth. de Paris*, 2° Série, t. II. and IV.

[2] Maška, *Mitt. der Anth. Ges. in Wien*, 1882, see also Virchow, *Zeitsch. für Ethn.* 1882, p. 300; and Schaafhausen, *Vereins der preuss. Rheinl. u. Westfalens*, 1883.

[3] Newton, *Geological Magazine*; also Klaatsch, *Zeitsch. für Ethn.* 1903.

[4] Owen, *Discovery of a human skeleton at Tilbury*, London, 1885.

[5] Schmerling, *Récherches sur les ossements fossiles*, 1833.

[6] Turner, *Rep. Brit. Ass. for the Adv. of Science*, 1863.

[7] Testut, *Bull. de la Soc. d'Anthr. de Lyon*, 1890, p. 152.

[8] Aymard, *Bull. Soc. Géol. de France*, 2° série, t. II. 1844, etc.; Sauvage, *Révue d'Anthropologie*, 1872, p. 289.

[9] *Reliquiae aquitanicae*; also *Bull. de la Soc. d'Anth. de Paris*, 2° Série, t. III. 1868.

[10] Fritz und Rokitanski, *Mitt. der Anth. Ges. in Wien*, 1872.

[11] Zittel (*Handbuch der Paläontologie* Bd. IV. 1893) unhesitatingly rejects the claims of a number of fossil crania: their claims to interest were largely based on their supposed geological antiquity. Incidentally it may be remarked, that Zittel (*op. cit.*) excludes from serious consideration the fossil skeleton of the Neanderthal, on the ground that it is of comparatively recent date.

[12] One of the most recent and exhaustive summaries of the literature of this subject is provided by Klaatsch, *Anatomische Hefte*, Bd. XII. 1902, pp. 552 et seq.

[13] *Die Vorgeschichte des Menschen*, 1904. Cf. also D. MacCurdy's review in the *American Anthropologist*, Vol. VI. No. 2, April—June, 1904.

[14] Broca, *Congrès internat. d'Anthr. et d'Arch. préhist.* 1867; *Compte rendu*, p. 398. Also Fraipont, quoted by Walkhoff, *Selenka's Studien*, Heft IX.

[15] De Quatrefages et Hamy, *Crania Ethnica*, p. 25.

[16] Filhol, quoted by de Mortillet, *Le Préhistorique*, p. 266.

[17] Nehring, *Zeitsch. f. Ethn.* 1895, Band 27, p. 573: also *Naturwiss. Wochenschr.* 1895, pp. 371 and 522.

[18] Makowsky, *Mitt. der Anthr. Ges. in Wien*, Bd. XXII. 1892, p. 73.

[19] Maška, *Congrès internat. d'Anthr. et d'Arch. préhist.* XII°. Session, 1900. *Compte rendu*, Paris, 1902, p. 130.

will be here confined to the Neanderthal,· Spy, and Krapina skeletons, since these present undoubted features of inferiority. .

I.· The crania. (*a*) The Neanderthal skull. The morphological characters of the Neanderthal skeleton have recently been studied by a master of anatomical knowledge and technique[1], to whose work acknowledgment must be made by all who are interested in the subject.
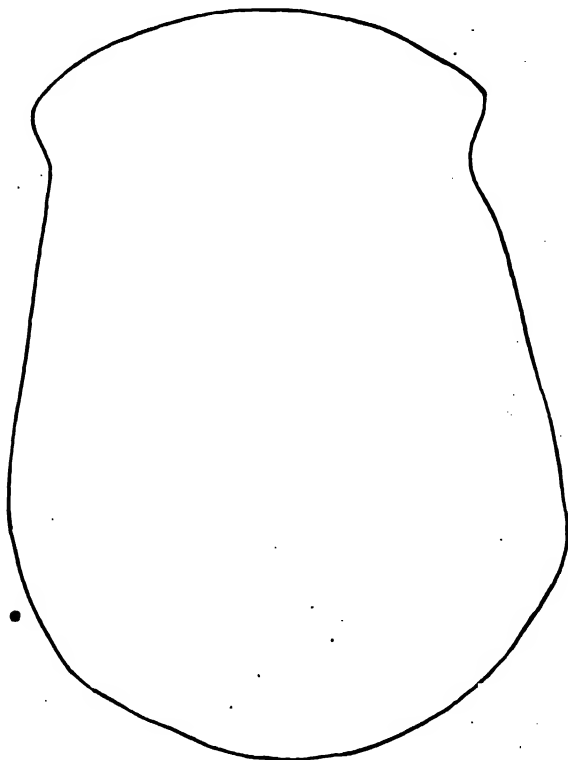
Fig. 325. The Neanderthal cranium, seen from above : the general features resemble those of the crania from Spy. (Cf. Figs. 329 and 330.)

(1) The length and breadth of the Neanderthal calvaria (for such it is, cf. Figs. 325, 326, 327) are quite comparable to those

[1] Schwalbe, *Der Neanderthalschädel, Bonner Jahrbücher*, Heft 106 : *v.* also Schwalbe, *Die Vorgeschichte des Menschen*, 1904.

of recent human crania (viz. 199 mm. and 147 mm. respectively).
The cephalic or breadth index thus provided is 73·9.   In general
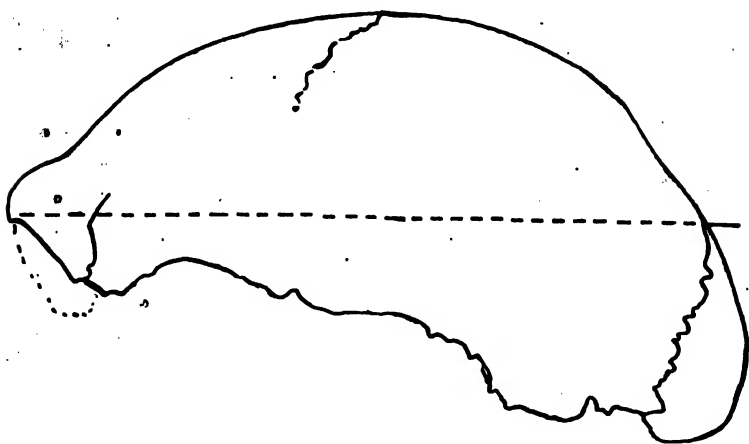
· Fig. 326. The Neanderthal cranium, seen from the left side: the prominent
brow-ridges and the flattened cranial arc resemble the corresponding features in the
Spy crania. (v. especially Fig. 329, and also 332.)

form, the calvaria is elongated; the sutures have been largely
obliterated by synostosis; and the most striking feature is the ·
massive character of the brow-ridges recalling those of the calvaria
of Pithecanthropus erectus: the prominence of the ridges is
enhanced by the narrowness of the frontal bone immediately
behind them (Fig. 325). Among recent crania, those of the ab-
original natives of Tasmania and Australia (cf. Fig. 284, Chapter
XVI.) most nearly reproduce this condition.

(2)   The median sagittal curve of the calvaria next claims
attention. (Cf. Fig. 327.) While in respect of length and breadth,
the ·Neanderthal calvaria falls within the range of variation of
recent human crania, it is quite otherwise as regards the height of
the cranial arc. The latter falls far short of the corresponding
curve in the crania of modern Hominidae, of whatever race. The
character is measured by determining the greatest height to which
the longitudinal arc rises above the line of maximum cranial length;
this height is shewn by the perpendicular line in Fig. 327, and
from the comparison of the perpendicular and horizontal lines, an

index of height (the Calvarial-height index, or Calotten-höhe'index of German writers) has been calculated.
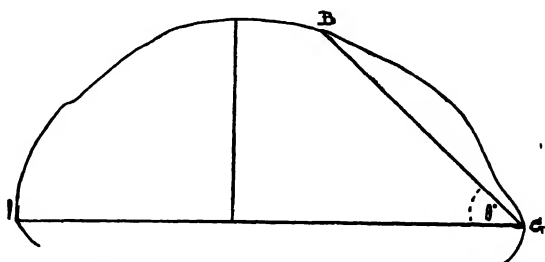
Fig. 327.　Tracing (after Schwalbe) of the outline of the Neanderthal skull : to demonstrate by means of the angular measurement (θ) the flattening of the cranial

In respect of this low flattened cranial vault, the Neanderthal calvaria while differing from the corresponding portion of all recent crania, is found to be closely imitated by the crania from Spy[1], less closely by the fragmentary calvaria from Krapina[2]. (Cf. Figs. 329 and 332.)　Indeed the association of these fossil remains in one species, is based largely on the community of this character. The height of the curve represents in the Neanderthal calvaria 40·4 % of the maximum calvarial (i.e. cranial) length : and the corresponding values for other specimens will be subsequently appended.

(3)　The prominence of the brow ridges naturally contributes to increase the flatness in appearance of the cranial vault.　This feature is indicated in the excessive length of the "pars glabellaris" of the frontal bone, comprised between the nasion and the most indented portion of the frontal bone.　The same features of flattened arc and prominent brow-ridges are factors which determine the value of a bregmatic angle (θ, Fig. 327), and in respect of these two characters the Neanderthal calvaria while associated with those of Spy and Krapina, is clearly distinguishable from all recent human cania.

The post-orbital narrowing of the skull when compared with the sudden widening which replaces it in the parietal region,

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[1] Schwalbe, *Der Neanderthalschädel*, p. 30.
[2] Kramberger, *Mitt. der Anth. Ges. in Wien*. Band 32, p. 202.

provides another criterion of distinction, and the comparison has been expressed in the form of a fronto-parietal index.

(4) A few other anatomical points in the comformation of the Neanderthal calvaria must next be appended. The frontal sinuses are bounded by much thickened walls. The parietal bone is distinguished by the very remarkable superiority in length of the temporal margin, over the coronal and other margins: this distinctly simian character is related to, and indirectly determines the small degree of curvature of the cranial vault[1].

The uppermost portion of the occipital squama bulges in the suggestive manner to which reference was made in describing the calvaria of Pithecanthropus erectus. This feature may be indicative of the former presence of a well-developed sulcus lunatus in the cerebral hemispheres[2]. This would be a simian feature.

The position of the torcular herophili corresponds so nearly with the external occipital protuberance that no simian relation can thence be claimed (in the Simiidae the torcular is distinctly nearer the foramen magnum than in the Hominidae): at the same time, the view that the Neanderthal skull is that of a microcephalic idiot is hereby refuted, for in the microcephalic skull, the torcular tends to assume in position much nearer the lambda than in the normal human skull. The fact that the capacity (estimated in the most careful manner) is represented as 1230 c.c. finally disposes of the last-mentioned suggestion, although this value assigns to the Neanderthal cranium a position among the lowest of the Hominidae. It is important to notice that the capacity is also relatively very small, when the comparatively large dimensions in length and breadth (of the cranium) are considered.

It has been pointed out that modern crania 200 mm. long and 145 mm. wide would have a capacity of about 1600 c.c., whereas the Neanderthal skull, 199 mm. long and 147 mm. wide, has a capacity of 1230 c.c. only. The variable factor is evidently the cranial height, which, as we have already seen, is extraordinarily small in the fossil specimen.

(b) The Spy crania. (Figs. 328, 329, 330.)

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[1] The ultimate cause of the lack of curvature of the vault will be found in the growth of the brain.

[2] Cf. Elliott Smith, *Rep. Brit. Ass.* 1904. The features of the endocranial cast (cf. p. 451) support this inference.

Turning from the Neanderthal remains to those of Spy, we may note that in several of the morphological features enumerated and reviewed above, the two are in close agreement. (1) Of the two crania from Spy, No. I. is however more distinctly *neanderthaloid* than No. II. Both are elongated flattened crania with massive brow-ridges. The outline of the squamous bone is not boldly curved as in recent human crania, but flattened as in the Simiidae. The projection of the occipital region indicates great development of the nuchal musculature, and also possibly indicates the former presence in the brain of a well-marked sulcus lunatus[1]. The tympanic bone is broad and is scored (as in the Gorilla) with distinct striate lines. Another simian feature is the extent of the glenoid fossa.

Fig. 328. One of the crania (No. 1) from Spy, seen from above. The cranium is elongated and post-orbital narrowing is marked.

[1] Cf. Elliott Smith, *Rep. Brit. Ass.* 1904.

(2)' Part of the mandible of No. I. has been preserved, and in morphological conformation this fragment fully bears out the indications given by the other parts of the skull.   In particular,

Fig. 329. Lateral view of the Spy cranium (No. 1). The prominence of the brow-ridges is very distinct.

the mental portion of the mandible is not prominent as in most recent Hominidae, but rather retreating.   This feature is sometimes observed in the mandibles of aborigines of Australia, and is particularly well marked in the mandible of No. I. of the four skeletons of Australian aborigines preserved in the Cambridge Collection.

Much stress has been laid upon the conformation of the genial tubercles, and Huxley (rather strangely) protested against the relevancy of such researches as were directed to this feature. Quite recently this subject has been approached from a new point of view by Walkhoff[1], who has investigated the disposition of the cancelli as revealed by the Röntgen rays.   The simian mandibular

[1] Selenka's *Studien*, Heft IX. ; cf. also the review by Klaatsch, *Anat. Hefte* 1902, pp. 622, 623.

symphysis is largely cancellous, without any very marked trabeculae; in recent Hominidae, the trabeculae are so closely aggregated at the symphysis as to give rise to a dark triangular patch when the jaw is examined: the Naulette[1] mandible is most distinctly simian in respect of the small extent of the dark patch, and the Krapina and
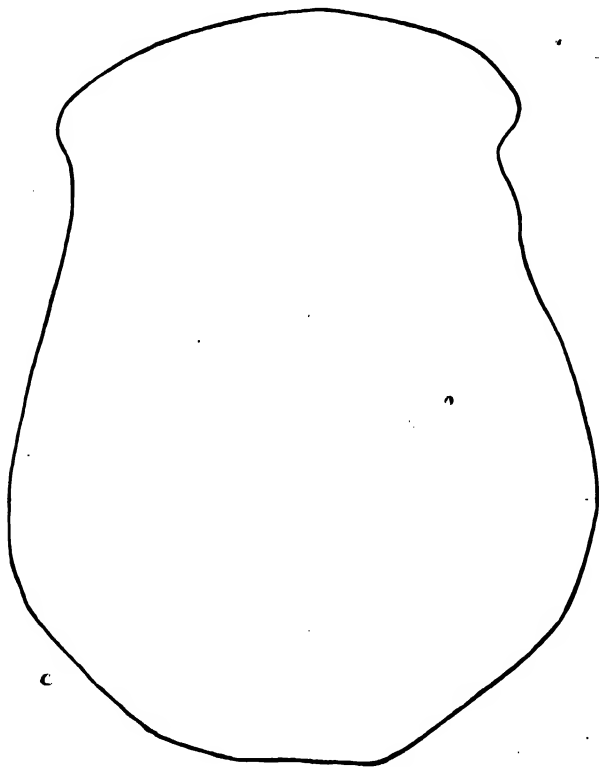
Fig. 330. The Spy cranium (No. 2) seen from above. Its characters, though less marked, resemble those of cranium No. 1. (Cf. Fig. 328.)

Predmost mandibles provide intermediate stages between the former and those of recent Hominidae. It is impossible here to discuss fully the bearing of these observations on the views held as to the speech of Homo primigenius, but the subject has been

[1] Cf. reference, p. 523.

discussed. Inasmuch however as speech is determined by the possession of a brain of a certain degree of complexity, as well as by that of the appropriate mandible, the problem will be at once recognised as very abstruse.

(3)   The canine teeth are not so superior in size to the adjacent teeth as to provide a more simian appearance, or evidence of more lowly affinities, than those of recent Hominidae.   The dental roots are long[1], and prominent on their labial surfaces.   The crowns of the lower molar teeth provide distinct evidence of simian affinities : for in the mandible of the skull No. I., the molar crowns increase in dimensions from before backwards : herein they agree with the corresponding teeth of the Simiidae, while differing from those of recent Hominidae (Topinard).

But in actual dimensions these teeth are smaller than the (upper) molar teeth of Pithecanthropus erectus, and fall far short of those of Gorilla.   In this connection, a word of warning must be added as regards statements made on this subject without clear specification of the molars (i.e. whether of the upper or lower -series) in question.   The foregoing remarks refer exclusively to the lower molar teeth.

As a complete series, the lower teeth of the Spy crania are characterised, (1) by their large size[2] (which surpasses that of modern white Hominidae, (2) by projection forwards of the incisor teeth, and (3) by the tendency to progressive increase backwards in size.

(c)   The Krapina calvaria.

From fragments obtained in the Krapina deposit it has been found possible to reconstruct part of a calvaria, though it is admittedly uncertain whether all the fragments originally formed part of the same skull or not[3].   The principal results of the investigation are summed up in the following notes.

The proportions of the skull (Fig. 331) shew that it was very distinctly brachycephalic, with an index (cephalic) of 85·5.   Herein a marked difference from the Neanderthal and Spy No. 1 crania

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[1] The length of the dental roots is a simian feature, as has been indicated by Tomes (*Dental Anatomy*), and Walkhoff (*op. cit. v.* p. 529 *supra*).

[2] Fraipont et Lohest, *Archives de Biologie*, Tome vii. p. 643.

[3] Kramberger, *Mitt. der Anth. Ges. in Wien*, Band 32, p. 202.
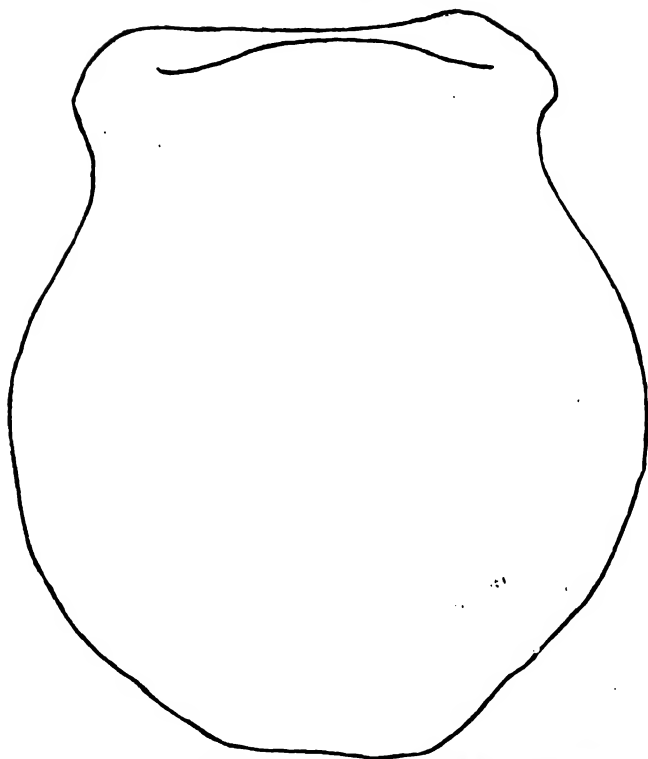
Fig. 331.   The Krapina skull, in norma verticalis (after Kramberger).
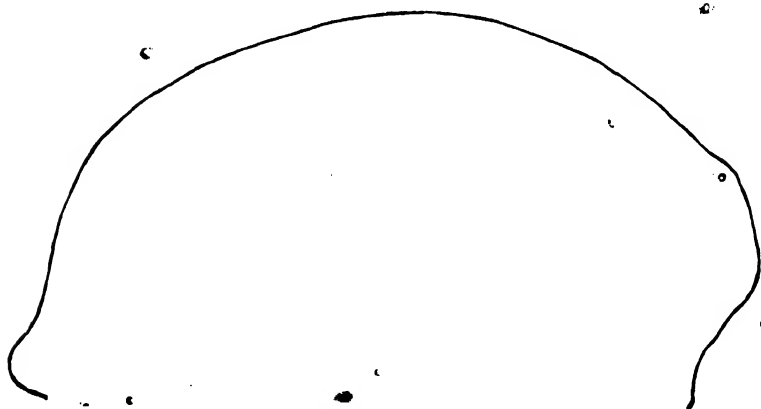
Fig. 332.   Tracing of the (reconstructed) Krapina skull, in norma lateralis (after Kramberger).

obtains, while the Krapina calvaria is more closely resembled by the Spy skull No. 2.

The brow-ridges (Fig. 332), like those of the Neanderthal and Spy crania, are massive, and indeed in this respect surpass the examples just mentioned, and even the calvaria of Pithecanthropus erectus is furnished with less bulky prominences in the corresponding situation. The frontal bone rises rather abruptly, so that the flatness of the sagittal arc, so marked in the Neanderthal skull, is in the present instance vestigial only: there is a median frontal keel closely resembling that of the calvaria of Pithecanthropus erectus. Not only do the Krapina and Neanderthal Spy crania resemble one another in respect of the brow-ridges, but resemblances also obtain (a) in the relative shortness of the margo lambdoideus of the parietal bone[1], but also (b) in the character of post-orbital compression, as denoted by the fronto-parietal index, and (c) in the conformation of the occipital bone, i.e. in the possession of a massive transverse torus.

The mastoid processes are but feebly developed, while there is distinct thickening of the tympanic bone.

Some of the chief dimensions of the Krapina calvaria and a few of the indices have been already mentioned. We may here note that the estimated length (from glabella to inion) is 197·5 mm. = the maximum breadth being estimated at 169 mm.

The fragmentary mandibles found with the cranial fragments yield evidence of the prognathism of the face and shew that there is close agreement between the Krapina men and those represented by the mandibles found at Shipka, Predmost and La Naulette[2].

As has been mentioned also, no less than 115 teeth were found with the cranial fragments. The adult (permanent) molar teeth are distinguished by the luxuriance of crenation on their crowns, a feature which allies these teeth to those of the Orang-utan, and in a smaller degree to the Chimpanzee, though not to the Gibbon or Gorilla. The dimensions of the molar crowns are distinctly in excess of the corresponding dimensions in modern European teeth,

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[1] See Schwalbe, *Der Neanderthal Schädel*, review by W.L.H.D. in *Man*, 1902, No. 129.

[2] Walkhoff, quoted by Kramberger, *Mitt.*, Bd. 32, p. 214.

but fall short of those of Pithecanthropus erectus, and of some aboriginals of Australia.

II.   Skeletal parts other than the skull.

(*a*)   The Neanderthal skeleton.

While recent research has disposed of the view that suggested a pathological explanation of the extraordinary cranial features of the Neanderthal man, it is rather striking that research has brought to light (in the bones of the upper limb and in the left arm particularly) evidence of disease, though this has not produced any effects that could be mistaken for specific morphological characters. Schwalbe thus finds that the left elbow-joint had been dislocated, probably in the early youth of the individual, and the comparatively stunted growth of the left humerus and ulna finds an explanation herein. The characters of the limb bones have been recently studied by Klaatsch[1], with the following results.

1.   The scapula presents few distinctive features. Retroversion of the neck of the glenoid cavity is very marked however : hereby the Neanderthal skeleton approaches that of the Orang-utan (but not those of the Gorilla or Chimpanzee) while diverging from the modern human type.

2.   The clavicle is slender : thus it contrasts with other parts of the skeleton, which, as a whole, is massive. Slenderness is not however a simian feature.

3.   The radius is very remarkable for the outward curvature of the shaft. This is a feature which distinguishes the Neanderthal skeleton from those of the modern Hominidae, and while it is admittedly a simian feature, yet it is shared by many of the lower Primates and even Eutherian Mammals with the Simiidae. The interosseous space is correspondingly wider than in recent Hominidae. (Cf. p. 311.)

4.   The olecranon and coronoid processes of the ulna are unusually massive[2].

[1] *Anat. Hefte*, 1900 and 1902.
[2] See Fischer, *Archiv für Anthropologie*, 1903.

5. The humerus: this bone is relatively short and accordingly perfectly human. In the proportions of the caput humeri a simian trait is found. But the olecranon fossa is imperforate. The angle of torsion is estimated at 35°[1]. In Veddahs this angle measures 30°, but only 9° in modern Europeans.

6. The hand is to all appearance perfectly human.

7. The pelvis provides no distinct evidence of morphological inferiority.

8. The femur (cf. the Spy femur, Fig. 333) is very stout, massive and distinctly curved: the articular ends are (relatively) of large size. In these characters, the bone contrasts strongly with the femur of Pithecanthropus erectus. The angle of femoral neck and shaft is towards the lower limit of the range of variation in modern human femora (*v.* Chapter XIII.). As regards the proportion of the transverse diameters of the articular ends of the bone to the total length, an association must be recognised with the femora of the Mongoloid races (e.g. the Japanese), not with those of Australian aborigines. The shaft is not platymeric, and in other characters of the shaft the bone diverges in type from that prevalent among the Australian aborigines, while it approaches that of the Mongoloid races. The deep patellar groove (fossa supra-patellaris) is a remarkable feature, of which the significance is not quite clear[2]. The sudden transition in transverse diameter from the shaft to the articular end has been particularly described by Klaatsch[3].

(B) The Spy skeletons[4].

(1) The clavicle is similar to that of the Neanderthal skeleton.

(2) The radius and ulna are bowed, so as to leave (as in the Neanderthal skeleton) a broader interosseous space. This is a simian feature.

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[1] Klaatsch, *Jahresber. für Anat. und Entw.* VII. 1902, XII. pp. 162, 166, 606; Fraipont, *Revue d'Anthr.*

[2] Klaatsch (*Zeitsch. für Eth.* 1903, Heft 6.) notes the presence of this fossa in femora of aboriginal Tasmanians in the Hunterian Museum in London.

[3] *Jahresber. für Anat. und Entw.* VII. 1902, XII. 162, 166, 606: *Anatomische Hefte*, 1900, p. 651.

[4] Cf. Fraipont and Lohest, *Archives de Biologie*, tome VII. p. 651.

(3)   The humeri are stout and heavy: the olecranon fossa is cribriform, but no definite perforation exists.

(4)   The characters of the femora (Fig. 333) are practically identical with those of the Neanderthal femur. In section the shaft is not flattened (platymeric), nor is the linea aspera unduly prominent. The third trochanter is not developed, but a representative of the depression known as fossa hypotrochanterica (which is frequent in fossil human femora) has been recognised. On the condyles the articular surface is prolonged far backwards and upwards as in certain primitive Asiatics[1].

(5)   The tibia is extraordinarily short, stout and strong but not platycnemic: the head is retroverted. Klaatsch detects in this tibia infantile and "Mongoloid," but not "Australoid" features.

Fig. 333.   Femur (*A*) of the Spy skeleton No. 1, compared with (*B*) a recent human femur (after Fraipont, *op. cit. v.* p. 535 *supra*). These femora should be compared with those of Pithecanthropus erectus (Fig.323) and of an Orang-utan (Fig.302).

(6)   The fibula. The chief point of interest lies in the fact that the long axis of the fibula seems to have crossed that of the tibia, instead of remaining parallel to it as in the Mongoloid races. Herein there is agreement between the Spy skeletons and those of recent white Hominidae. But it must be remarked that the evidence for the statement is based on the characters of only a fragment of the fibula.

(7)   For the os calcis, Leboucq (quoted by Klaatsch) records an index which shews that the bone is either less elongated, or broader than modern calcanea. The former condition is simian.

(8)   The tarsal bones of the Spy skeleton No. 2 suggest that the foot was large, but not notably different from those of modern Hominidae.

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[1] Negritoes and Punjabis; cf. Charles, *J. A. and P.* Vol. XXVIII. p. 1.

(*b*)   The Krapina skeletons.

As to the limb bones of the Krapina skeletons little or no information is as yet available. Kramberger[1] figures a patella, and part of an immature scapula: Klaatsch[2] notes that a navicular bone has been found, but this does not yet appear to have been minutely studied. A child's clavicle is also stated to have been preserved intact.

General conclusions from the foregoing descriptions.

A review of the characters of the fossil remains from the Neanderthal, from Spy, and Krapina leads to the conclusion that the individuals thus preserved possessed a combination of morphological features which places them in a distinctly lowlier position than the modern Hominidae. If one examines the history of this subject one finds that just as the announcement (in 1894) of the discovery of Pithecanthropus erectus was the occasion of stormy debates as to its exact nature, so at an earlier date (1857) the precise status of the Neanderthal fossil skeleton furnished material for discussions no less protracted nor, it may be added, less heated. And just as contemporaneous opinions in 1894 on the question of the nature of Pithecanthropus erectus could be ranged in three district camps (cf. p. 511), so also anatomists and anthropologists were divided in opinion forty years previously, upon the question of the Neanderthal man. An interesting comparison with the table drawn up in the case of Pithecanthropus erectus to shew the different categories into which the several observers are divisible, is provided by Schwalbe[3] and is here appended.

I.   The Neanderthal skull is not typical of a special variety, but is a sporadic case, which departs unusually far from the normal.

   (*a*)   The modification in form is the result of premature cranial synostosis.   Barnard Davis.

   (*b*)   The individual was idiotic.   Blake, C. Vogt and Pruner-Bey (at one epoch), v. Hölder, Zittel.

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[1] *Mitt. loc. cit.* Taf. 3 and 4.
[2] *Anatomische Hefte*, 1902.
[3] *Der Neanderthal Schädel*, pp. 56–57.

(c)   The characters have been modified by disease.   Virchow
        (1872), v. Ranke.

II.   The Neanderthal skull is within the ordinary range of
variation of human crania of modern times.

(a)   The recent skull of a Cossack.   Mayer.

(b)   The skull of a member of an ancient but historic
        race :

(i)   Ancient Kelt or Teuton.   Pruner-Bey (at one epoch).

(ii)   Ancient Dutch or Frisian: a Batavian.   Wagner.
        „   „   „   a Frisian.   Virchow (1876).

(c)   The skull of an individual of a primitive human race,
        which is however linked by " neanderthaloid "
        forms of skull to the most primitive of existing
        races.

(a)   Similar to aborigines of Australia.   Huxley, Lyell,
        C. Vogt (at one epoch), De Quatrefages, Hamy.

(b)   Representative of a particular race, viz. that of
        Cannstalt, De Quatrefages, Hamy.

(c)   (i)   A primitive savage race, clearly differentiated
        from modern Hominidae.   Schaafhausen, Fraipont,
        Lohest.

(ii)   A race distinguished from modern white races
        just as the modern negro is from the modern
        white man ; the Neanderthal race.   De
        Mortillet.

III.   The Neanderthal skull represents a form which is
distinct in species and perhaps even in genus from all existing
Hominidae.   King, Cope, Schwalbe.

We may now give some more detailed evidence as to the
agreement in general conformation of the several examples
previously described apart.   I.   First, one may consider the actual
length and breadth of the specimens, as shewn in the following
table :.

		Length	Breadth
(1)	Neanderthal.	199	147.
(2)	Spy, No. I.	200	140.
(3)	Spy, No. II.	199	150.
(4)	Krapina.	197·5[1]	169[1].

II. Secondly, the fronto-parietal index, expressive of the relation of the minimal post-frontal, to the maximum parietal breadth, provides the following figures.

(1)	Neanderthal	...	...	...	...	...	73·1.
(2)	Spy, No. I.	...	...	...	...	...	71·2.
(3)	Spy, No. II.	...	...	...	...	...	71·2.
(4)	Krapina ...	...	...	...	...	...	64·7 ! .
(5)	Average value of the preceding ...			...	...	...	70.
(6)	Average of lowly Hominidae[2]		...	...	...	...	77.
(7)	Pithecanthropus erectus ...		...	...	...	...	65·4.

III. In the third place, the flattening of the cranial arc, as expressed in the calvarial-height index, yields material for comparison as follows.

Calvarial-height index (the height of the calvaria as a percentage of its length).

(1)	Neanderthal	...	...	...	...	...	40·4.
(2)	Spy, No. I.	...	...	...	...	...	40·9.
(3)	Spy, No. II.	...	...	...	...	...	44·3.
(4)	Krapina (the mean of two determinations[3])			...	46·1.
(5)	Average value (from the four preceding indices)			42·9.
(6)	Lowest figure provided by a recent human skull			52
(7)	Highest figure provided by an anthropoid ape (Simiidae)			37·7.
(8)	Pithecanthropus erectus	...	...	...	34·3.

The gap separating the fossil from the recent Hominidae is thus represented by a difference amounting to nearly 20 %.

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[1] Estimated, not directly measured.

[2] Aborigines of Australia. This index is not however an absolutely safe means of differentiating the Simiidae from the Hominidae (Schwalbe). The Krapina specimen provides an extraordinarily low figure for this index.

[3] From two reconstructions of the calvaria. There is some ambiguity in Kramberger's table in p. 203 of his memoir cited on p. 531.

IV.　Fourthly, the prominence of the supra-orbital ridges is denoted by means of an index expressive of the relation of the glabellar to the cerebral part of the frontal arc[1].　The figures are:

(1)　Neanderthal ...　　...　　...　　...　　...　　... 44·2·
(2)　Spy, No. I.　...　　...　　...　　...　　...　　... 41·5.
(3)　Spy, No. II. ...　...　　...　　...　　not determinable.
(4)　Krapina not determinable, but probably greater than ·45.
(5)　Recent Hominidae (range) ...　　...　　... 21 to 32.
(6)　Simiidae　...　　...　　...　　...　　... 30 to 40.
(7)　Cercopithecidae　...　　...　　...　　..., 50 to 60.

V.　Fifthly, the bregmatic angle is expressive of the degree of curvature of the cranial arc, as well as of the prominence of the brow-ridges.　This angle has provided the following data:

(1)　Neanderthal　...　　...　　...　　...　　... 44°.
(2)　Spy, No. I.　　...　　...　　...　　...　　... 45°.
(3)　Spy, No. II.　...　　...　　...　　...　　... 50° 30′.
(4)　Krapina　...　　...　　...　　...　　...　　... 51° 30′.
(5)　Recent Hominidae (range of variation) ...　　... 53°—66°.

The preceding list might be very considerably extended, but is adequate to demonstrate the agreement in conformation upon which so much stress has been laid.

As a final summary of cranial characters, the following classification will be found both instructive and suggestive.

(a)　In respect of certain characters, Homo primigenius falls within the range of variation recognised in recent human crania. Such characters are,

(1)　The cephalic index.

(2)　The relation between the minimal frontal and maximal parietal breadth (expressed by the fronto-parietal index).　The Krapina skull forms an exception to this statement, for in this character it falls below Pithecanthropus erectus.

(3)　The breadth of the inter-orbital space.

[1] Cf. Schwalbe, *Der Neanderthal Schädel*, p. 29.

(β) Certain characters, such as the following, are distinctly simian, for they do not occur in recent human crania, though found in the crania of Homo primigenius and those of apes (Simiidae):

(1) The excessive length of the pars glabellaris of the frontal bone.

(2) The very large proportion of the frontal component of the median sagittal cranial arc.

(γ) Finally, there are characters which place Homo primigenius in a position intermediate between recent Hominidae and the Simiidae. Such characters are:

(1) The flattened curve of the cranial vault. (Cf. Fig. 327.)

(2) The low numerical value of the bregmatic angle. (Cf. Fig. 327.)

(3) The small vertical height of the bregma above the glabello-occipital line. (Cf. Fig. 327.)

(4) The low numerical value of the frontal angle.

The evidence derived from the limb bones has already been surveyed. It should be added that Pearson[1] estimates the stature of the Neanderthal man at 1629 mm., and that of the male skeleton from Spy at about 1600 mm., figures representative of stature below the average for Western Europe at the present day.

For the differences between Homo primigenius and recent Hominidae a specific value can therefore be justly claimed. Klaatsch[2] insists on this point, but at the same time records his conviction that the differences do not point to Pithecanthropus erectus and the Simiidae as the precursors of the Hominidae. Klaatsch postulates the existence of an ancestral series, parallel to that which has culminated (according to Klaatsch) in the Simiidae, and through which the Hominidae are connected with an ancestor which they share in common with the Simiidae.

It cannot be said that this opinion is unjustifiable, much less can it be disproved. At the present time one has to select that view which appears on the show of evidence to be the most probable. With such considerations in mind, it must be urged

[1] *Phil. Trans.* 192 A, p. 205.
[2] *Jahresberichte für Anat. u. Entw.* VII. 1902, XII.

that Klaatsch has still to produce evidence, in the form of specimens (pithecoid, and yet not referable to the Simiidae) which have figured in the line of descent between the hypothetical ancestor and the Hominidae. Such evidence may never be forth-coming: it seems as if only palaeontological discovery were capable of providing it. But I feel assured that should the missing links come to light, and be subjected to a morphological analysis, some at least would present many features (such as those of the cerebrum) which would compel the observer to group them with the Simiidae rather than with any other known family of the Primates. They would, moreover, be further removed from the Hominidae than is Pithecanthropus erectus.

Additional evidence may at a later date be derived from the study of casts of the endocranial cavities of the preceding calvarial fragments. In connection with this subject, reference must again be made to the peculiar conformation of the left occipital region of the Neanderthal brain[1], as judged by the endocranial cast; and also to the occasional discovery of semi-fossilised brains in very ancient crania. The best-known instances are provided by very ancient human remains in Egypt; allusion has already[2] (cf. Chapter xv.) been made to Elliott Smith's researches on such cerebral fragments as have been thus preserved. Professor Montelius informs me that the brain is sometimes partially preserved in crania exhumed from the Scandinavian peat-deposits; and a similar instance is recorded in the case of a cranium from one of the famous mounds in Ohio[3].

[1] p. 451.   [2] p. 451.   [3] p. 451.

CHAPTER XVIII.

CONCLUSION.

WITH the foregoing review of human palaeontology the survey proposed in the introductory Chapter (p. 11) of this volume is brought to a conclusion. It is appropriate to summarise the general inferences which result from the balance of evidence thus set forth.

I. From that evidence it appears that the close association of the Hominidae with the higher Primates (Simiidae) has been continuously confirmed by the researches of the last forty years. But while it is shown that the Hominidae have in their evolution passed through a stage which is better reproduced by the Simiidae, than by any other of the Primates, it is practically certain that the modern Simiidae did not themselves figure in the ancestry of Man, and that they are themselves specialised in a high degree, more specialised in many ways than the Hominidae (cf. Chapter V. p. 120), and more specialised than their own ancestors. As Klaatsch puts it[1], the ancestors of the modern Simiidae were more anthropoid than the actual Simiidae, just as the ancestor of the Hominidae was more pithecoid than modern Man. And the balance of evidence indicates that the line of human ancestry would, were the material still available, be traceable down to the lowest Primates (Lemuroidea[2]) and even to the lowest Mammals[3].

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[1] *Bericht der* xxxii. *Versamm. der Deutschen. Anthr. Ges. in Metz*, 1901 ; *Arch. für Anth.*, Band. 27, ss. 102 *et seq.* Also *Bericht &c.* Dortmund, 1902. *Arch. für Anthr.* Band. 28, s. 136.

[2] It must not be forgotten that the Lemuroidea and Anthropoidea are distinguished very clearly by the characters of the blood-serum, as demonstrated so ably by Nuttall, Friedenthal and others. But the modern Lemuroidea are of course specialised, as compared with the ancestral stock whence they and the Hominidae derive their common origin.

[3] Cf. Cope, *op. cit.*, *vide* Chapter VI. p. 153.

Moreover, it is undeniable that the Hominidae have retained in hand and foot some features of an early ancestor, from which they have departed less in type than have the (modern) Cercopithecidae and Simiidae. But detailed information on these points is still lacking.

II. In the second place it is evident that the Hominidae, if retraceable to an ancestral stage which is common to them and the Lemuroidea, have most probably inhabited the earth since the early Tertiary epoch. There seems no means of escaping this conclusion, except by remembering the possibility that in the period mentioned, the representative of the modern Hominidae might be so different from Man, and so like the lemuroid ancestor, that it would be difficult to recognise its true nature. There comes a point therefore at which we should fail to recognise the human ancestor, and this point will, I believe, be found to fall within the later Tertiary period, and probably in its Pliocene division.

III. Thirdly, when we examine the evidence bearing on the comparative morphology of the human races, we shall find that we are confronted with another set of problems similar to the preceding. While there is little doubt that simian features are not all concentrated in any single race (this was pointed out by Turner some years ago[1]), yet there can be no doubt that the aborigines of Australia and Tasmania have (up to the present) furnished the examples of the greatest concentration of ape-like characters. But we must not therefore conclude that these aborigines present us with a fac-simile of a human ancestor; for these very aborigines are themselves remarkably specialised, in adaptation to their surroundings. Our conclusion will be more correct if we make allowance for this specialisation, and await the advent of details regarding the structure of the Asiatic Negritoes and several African races (and particularly some of the pygmy types). To all alike the ancestral human characters have in greater or lesser degrees been transmitted, and we must gather up threads of evidence from all, and not from one only in the attempt, to arrive at a reliable reconstruction of the parent form.

[1] *Chall. Rep.* XLVII.

From the preceding paragraph it will be correctly inferred that I am not prepared to accept Schoetensack's view[1] that the Hominidae have been evolved in the Australian continent. Africa and southern Asia present at least equal claims to have been the scene of that phenomenon; and though a decision between the two appears to me in favour of the latter continent (Asia), there is much to be urged on both sides. The New World seems, from the evidence at present available, to possess no such claim.

IV. The factors which have determined the evolution of the various modern human types may be summed up under the comprehensive, but somewhat vague term, "environment." Of these influences one of the most potent is geographical situation, with its attendant advantageous or disadvantageous relations to temperature and food supply, and with indirect effects on habits and temperament. By the latter, the action of such secondary factors as sexual, physiological, and other modes of selection, must be profoundly influenced.

By such conditions the path of morphological evolution has been determined in the past, and in the future it will be modified by similar influences, masked though they may be in the more civilised of the Hominidae[2]. The latter hold an absolutely unique position among the Mammalia (and for that matter, in the whole biological world); on them, specialisation of the cerebrum has conferred an altogether exceptional development of self-consciousness. When we reflect that with this are combined ability to formulate and communicate, and power to record ideas, the immense advantages of such specialisation become apparent. Thus it is that the highly-civilised races have it so largely in their own hands, not merely to adopt ordinary means of adaptation which they share with other races and animals, but to employ methods of self-preservation hitherto unattainable by any organism.

The future evolution of the Hominidae seems likely to occur in populations of mixed origin; for the least mixed races (aboriginal Australian, Negrito, Bush native and Eskimo) are without exception diminishing in number and are doomed to early extinction.

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[1] *Z. für Ethn.* Band 33.

[2] This statement is not in full accord with Huxley's view, as expressed in the *Romanes Lecture*, 1893, pp. 32 *et seq.*

Morphologically, it appears that specialisation of the cerebrum (particularly of the neo-pallium) is still an indispensable condition of human survival; but it is hard to see how subsequent advances in gross anatomy are to be effected, except by increasing still further the complexity of the neopallial folds. It seems therefore probable that the future changes will affect the minute structure of the neopallial cortex.

Concurrently, diminution in the maxillary and mandibular skeleton and apparatus may be carried further than at present, but this brings out a consideration of great importance. It is to be remembered that for the proper maintenance of each system, adequate nutrition is a prime necessity; and maxillary reduction will be limited by this factor. So also, the future modification of the cerebrum will be largely dependent on its blood-supply, which in turn is related to the quality of the cardiac muscle and various physiological factors.

From these considerations it is evident that due and proper reaction between the vascular, nervous, and other systems is a condition of survival. Such physiological equilibrium can only be obtained by the proper exercise of its functions by each system of tissues involved. We are thus led to the conclusion that cerebral specialisation, the prime factor in the future, as it has been in the past evolution of the Hominidae, is ultimately dependent on what may, in the widest sense, be termed hygienic conditions.

By the exercise or neglect of these the future evolution of the Hominidae will be determined: failure to comply with such demands will eventually lead to extinction.

GENERAL INDEX.

NAMES OF AUTHORS QUOTED.